ORNITOLOGÍA NEOTROPICAL
(2022) 33: 44–52

ORIGINAL ARTICLE

Sociedad de Ornitología Neotropical

# URBAN SOUTHERN HOUSE WREN (*TROGLODYTES AEDON MUSCULUS*) NESTING IN APPARENTLY UNSUITABLE HUMAN-MADE STRUCTURES: IS IT WORTH IT?

**Eduardo R. Alexandrino[1,2*] · Gabriele A. da Silva[1] · Milena C. Corbo[3] · Brás A. Demuner[1,4] · Judit K. Szabo[5,6]**

[1] Instituto Nacional da Mata Atlântica – INMA. Av. Augusto Ruschi 4, 29650-000, Centro, Santa Teresa/ES, Brazil

[2] Universidade de São Paulo - USP, Escola Superior de Agricultura "Luiz de Queiroz" - ESALQ, Laboratório de Ecologia, Manejo e Conservação de Fauna Silvestre - LEMaC, Av. Pádua Dias, 11, Caixa Postal 09, 13418-900, Piracicaba/SP, Brazil

[3] Independent researcher. Rua Engenheiro Isac Garcez, 525, Vila Caminho do Mar, São Bernardo do Campo/SP, Brazil

[4] Citizen scientist

[5] Programa de Biodiversidade e Evolução, Universidade Federal da Bahia, Instituto de Biologia, 1154, R. Barão de Jeremoabo, 668, 40170-115, Ondina, Salvador/BA, Brazil

[6] Research Institute for the Environment and Livelihoods, Charles Darwin University, Casuarina, NT 0909, Australia

E-mail: Eduardo R. Alexandrino · eduardoalexandrino@hotmail.com

**Abstract** · Free-living birds in cities interact with humans and human-made objects. Here, we investigated whether nesting in human-made structures that are physically unstable and prone to frequent human intervention benefits urban Southern House Wrens (*Troglodytes aedon musculus*). First, we describe the behavior of individuals that repeatedly attempted to nest in a motorcycle helmet (an unsuitable structure) based on *ad libitum* observations and camera trapping. We also reviewed nesting records of this wren throughout Brazilian cities deposited in crowdsourced citizen science platforms, such as Wiki Aves, eBird, and iNaturalist. During our field study in November and December 2019, wrens attempted to build a nest in the helmet for eight days. Each attempt was interrupted by the removal of the helmet. We recorded 103 videos of nesting activity, including three days of high nest-building effort (up to 68 twigs deposited inside the helmet within a 6-hour period) and high territory-defense efforts. Both behaviors were sometimes followed by one of four types of vocalizations (contact call, complete song, incomplete song, or sub-song). We found 372 Southern House Wren nesting records in online citizen science datasets: 100 were in urban areas with 86 nests built on 24 different human-made structures. Most nests (N = 71) were in what we deemed as stable structures (safe from human intervention) and 34 of them (47.8%) likely bred successfully (i.e., fledglings present). Only seven nests were built on unstable and unsafe structures, and four (57.1%) of these had sufficient evidence of successful nesting. Although nesting in unsuitable places in cities is less frequent, their breeding success is comparable with nesting in suitable places. Therefore, the nesting of the Southern House Wren in human-made structures might be of benefit, even if they eventually become ecological traps due the risk of human intervention. Our study adds knowledge about the life history of the Southern House Wren in urban environments.

**Resumo** · **Corruíras urbanas (*Troglodytes aedon musculus*) nidificando em estruturas antrópicas aparentemente inadequadas: isso vale a pena?**

Aves de vida livre em cidades interagem com humanos e seus objetos. Aqui, investigamos se o ato de nidificar em estruturas antrópicas fisicamente instáveis e sujeitas a intervenções humanas é, de algum modo, benéfico a corruíras (*Troglodytes aedon musculus*) que ocorrem em cidades. Primeiro, nós descrevemos os comportamentos realizados por indivíduos que tentaram nidificar repetidamente em um capacete de motociclista (uma estrutura inadequada), tendo base observações *ad libitum* e armadilhamento fotográfico. Após, também revisamos registros de nidificação da espécie feitas em cidades brasileiras e que foram depositadas em plataformas de ciência cidadã *crowdsourcing*, como Wiki Aves, eBird e iNaturalist. Durante o estudo de campo, em novembro e dezembro de 2019, as aves tentaram construir seu ninho no capacete por 8 dias, sendo que cada tentativa era interrompida por causa do uso do capacete pelo seu dono. Nós registramos 103 vídeos que capturaram as atividades de nidificação, dos quais observamos 3 dias de grande esforço para a construção do ninho (até 68 gravetos foram depositados no capacete em um período de 6-h) e grande esforço de defesa territorial. Estes comportamentos eram, às vezes, acompanhados da emissão de um dos quatro tipos de vocalização (chamado, canto completo e incompleto e sub-song). Nós encontramos 372 registros de ninhos de corruíras nas plataformas de ciência cidadã: 100 eram de área urbanas sendo que 86 estavam construídos em uma das 24 diferentes estruturas antrópicas que identificamos. A maior parte dos ninhos (N = 71) estavam em estruturas estáveis e seguras contra intervenções humanas e em 34 deles (48,8%) houve provável sucesso reprodutivo (i.e., presença de filhotes). Apenas sete ninhos estavam em estruturas instáveis e inseguras, mas em quatro deles (57,1%) havia evidências de provável sucesso reprodutivo. Embora a nidificação em estruturas inadequadas seja menos frequente, o sucesso reprodutivo nestas estruturas é equivalente ao que ocorre em estruturas consideradas adequadas. Portanto, a nidificação de corruíras em algumas estruturas antrópicas pode ser vantajosa para a espécie, mesmo que eventualmente elas se tornem armadilhas ecológicas devido ao risco de intervenção humana. Nosso estudo soma conhecimento sobre a história de vida da espécie no ambiente urbano.

**Key words:** Adaptation · Amateur ornithologist · Collaborative citizen science · Neotropical passerine · Nesting behavior · Urban ecology

Submitted 23 December 2020 · First decision 5 May 2021 · Acceptance 28 January 2022 · Online publication 22 March 2022

Communicated by Ernesto Ruelas Inzunza 

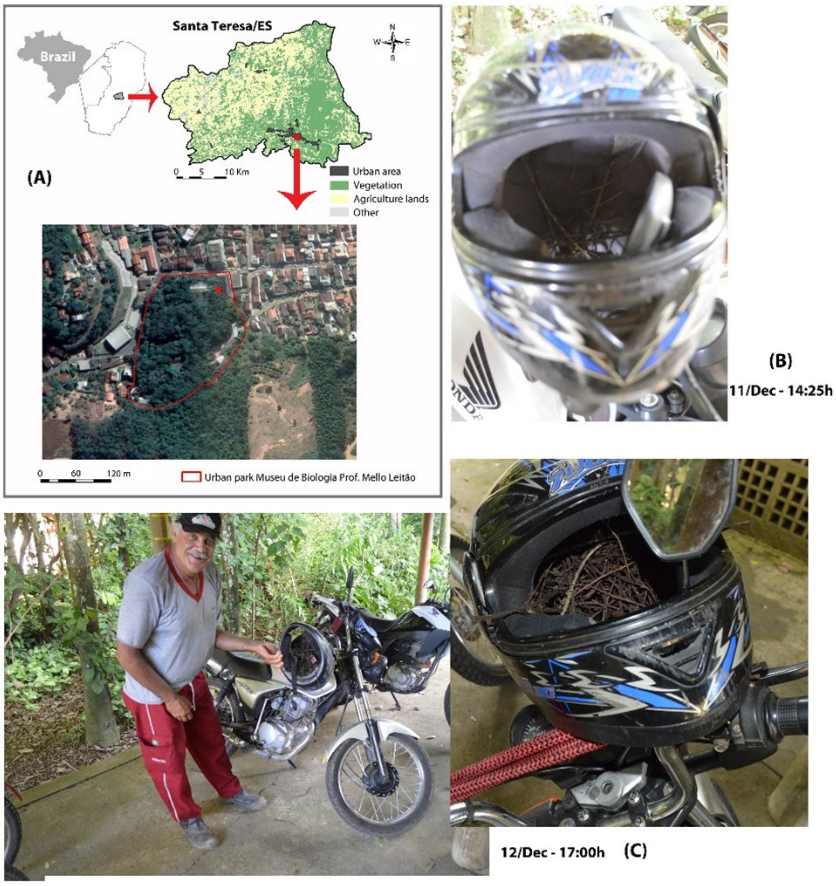


**Figure 1**. a) The Museu de Biologia Prof. Mello Leitão, located in the urban area of Santa Teresa municipality, Espírito Santo state, Brazil. The red dot in the aerial image indicates the motorcycle parking lot where the Southern House Wren attempted nesting inside a motorcycle helmet for eight days. b) Materials observed in the early afternoon of 11 December 2019. c) The citizen scientist showing his helmet with the nest at the end of the sampling period on 12 December 2019.

## INTRODUCTION

Some urban birds can take advantage of human-provided substrates for nesting, which represents an example of a beneficial interaction with humans (Mainwaring 2015, Tomasevic & Marzluff 2017, Batisteli et al. 2020). Selecting a site where the nest is inaccessible or visually hidden from predators can increase reproductive success substantially (Martin 1993). However, birds seeking to minimize the threat of predation may increase their interaction with humans, thereby decreasing their breeding success (Møller 2010, Mainwaring 2015, Pizo 2018, Ribeiro et al. 2019, Reynolds et al. 2019).

The trade-off between predation and human intervention is not necessarily a compromise of opposites: for instance, some people allow these birds to continue their breeding activities (Zuberbühler 1953, Muralidhar & Barve 2013, Pizo 2018, Ribeiro et al. 2019), whereas others may relocate (Salles 1986) or manipulate nests (Viana et al. 2012). Sometimes breeding is intentionally or unintentionally interrupted by people because of the need to use the structure or object where the nest is built (Carvalho Filho 1998, Mainwaring 2015, Pizo 2018, Reynolds et al. 2019). Therefore, it is crucial to understand how different species behave in cities, which adaptations are advantageous, and how birds take advantage of human-made structures for nesting (Santiago-Alarcon & Delgado-V 2017, Piratelli et al. 2017).

The Southern House Wren (*Troglodytes aedon musculus*) is a small (10–13 cm, 10–15 g) insectivorous passerine that is a common breeder in Neotropical cities (Sick 1997). This cavity-nesting bird exhibits considerable plasticity in nest-site selection and substrate use, and it is often reported using natural or artificial substrates close to humans (Skutch 1953, Sick 1997). However, when wrens nest in places deemed unsafe by humans, such as electric machinery, electric boxes, small openings in automobiles, or under sharp surfaces (Zuberbühler 1953, Skutch 1953, Sick 1997), people ask themselves whether birds will reproduce successfully. Therefore, paying more attention to unusual nesting locations and behavior observed in cities can help understand the potential of the Southern House Wren to survive and successfully reproduce in an urban ecosystem, and can also provide information to people about ways to coexist with birds that breed in urban areas.

Here we evaluate whether nesting in human-made structures in an urban environment confers a reproductive benefit to the Southern House Wren. First, we describe a case study of wrens repeatedly attempting to nest inside a motorcycle helmet in an urban park. Then, we analyzed hundreds of nest photos from three citizen-collected online datasets to document which human-made objects and surfaces wrens use as nest sites in cities and which of these can be considered unsafe. Based on these data, we evaluate the potential breeding success on these sites based on the presence of nestlings or other information provided by citizen scientists themselves.

## METHODS

**Field observations.** We observed nesting attempts of South-

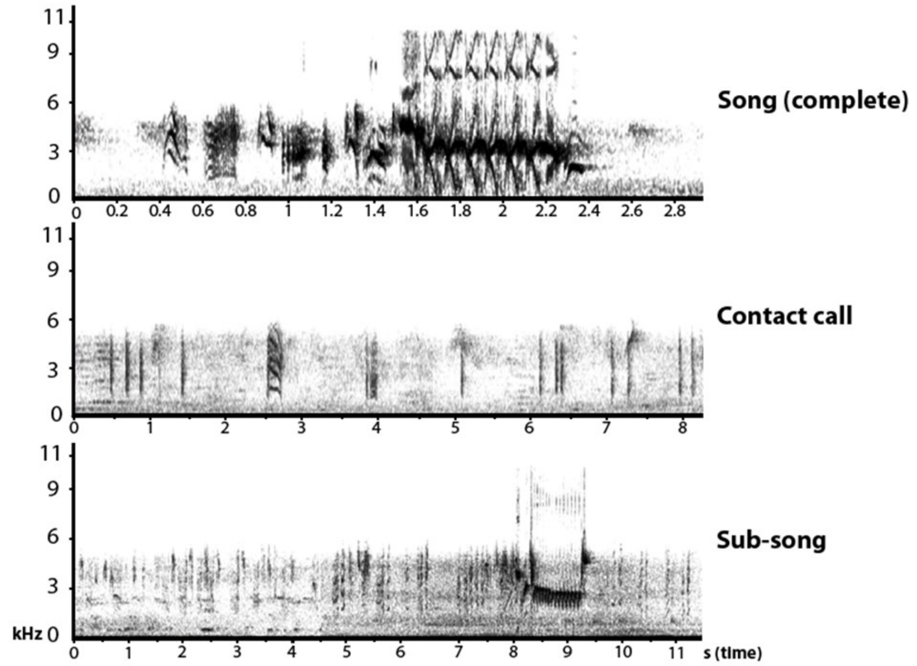


**Figure 2**. Sonograms extracted from videos recorded by a camera trap to illustrate Southern House Wren vocalization types: a) complete song, b) contact call, and c) sub-song. Incomplete (interrupted) songs are not illustrated. The videos were taken at the urban park Museu de Biologia Prof. Mello Leitão, in Santa Teresa municipality, Espírito Santo state, Brazil, where a camera was installed in front of a helmet that was used by the species during the nesting attempts.

ern House Wrens in the urban park Museu de Biologia Professor Mello Leitão (MBML), located in the urban area of the Santa Teresa municipality (694,534 $km^2$), Espírito Santo state, Brazil (40°15'–40°45'W and $19^o45'–20^o45'$S). Less than 1.5% of this municipality is urbanized (Prefeitura de Santa Teresa 2020, Figure 1a). Although the forested hills surrounding the urban area around MBML have been under urbanization pressure (MapBiomas 2020), the park's vegetation is in good condition and supports a variety of native animals within the city's limits (Silva & Martinelli 2011, Wiki Aves 2020, iNaturalist 2021).

Our observation site is a 12 $m^2$ area for motorcycle parking near the park entrance, protected by a small roof and surrounded by buildings and trees (Fig 1a). This small parking lot is exclusively used by a few MBML employees. The gardener of the park (BAD), who is also the citizen scientist author of this article, habitually leaves his motorcycle helmet on the handlebars of the motorcycle in the parking lot, 1.5 m above the ground.

We conducted observations on 19 weekdays between 25 November and 19 December 2019 using the following three methods: (1) BAD conducted *ad libitum* observations on weekdays from 25 November to 10 December 2019; (2) ERA conducted a*d libitum* observations around the parking lot on 11 December (2 hours of sampling effort in total), and on 17, 18, and 19 December 2019 (30-min total, 10-min each day) using Bushnell 8 x 42 binoculars from a distance of 10 m; and (3) we used a Stealthcam STC-U840IR 2010 camera trap with 640 x 480 pixels VGA video resolution and mono sound recording to record 20 s videos via a motion sensor trigger and with 10 s intervals between videos, ensuring as little disturbance as possible. We set the camera in front of the helmet on 12 December (09:00 h–17:00 h BRT), 13 December (06:00 h–17:00 h), and 16 December 2019 (09:00 h–11:00 h and 12:00 h–16:00 h), affixed on a pole 1.2 m away and pointing towards the helmet's face opening.

Between 25 November and 11 December, and on 16 December, BAD had the same routine on the 12 working days: he parked his motorcycle at around 07:00 h and removed it at around 11:00 h to leave for lunch. He then returned at 12:00 h and kept his motorcycle and helmet on the same spot until the end of his workday, at around 17:00 h. Every time BAD used his motorcycle, he also used the helmet. His routine changed on 12 and 13 December, when he did not use the motorcycle during the lunch period (i.e., the helmet stayed on the same spot from 07:00 h– 17:00 h) in order to capture the nest construction process on camera for a longer time.

**Citizen science records.** We analyzed Southern House Wren nest records from Wiki Aves (wikiaves.com.br), eBird (ebird.org), and iNaturalist (inaturalist.org), three citizen science platforms that are popular in Brazil for crowdsourced bird observations. On Wiki Aves, we searched for *Troglodytes musculus* records. This Brazilian platform follows the taxonomic criteria of the Brazilian Committee of Ornithological Records (Pacheco et al. 2021). As eBird and iNaturalist follow the nomenclatural recommendations of the South American Classification Committee (Remsen et al. 2020), on these international platforms we used *T. aedon* or *T. a. musculus* as search terms. From eBird and iNaturalist, we selected all photographic records for Brazil and visually examined them for the presence of nests. Wiki Aves accepts only records from the Brazilian territory. We filtered Wiki Aves data for photos and nesting records. We conducted these searches on 7 December 2020 and found 1103 records on eBird, 539 on iNaturalist, and 310 on Wiki Aves, corresponding to the period from 30 November 1999 – 3 December 2020.

**Data analysis of field observations.** Because the videos were short and only captured images after the motion sensor at the front of the camera was activated, many of the bird

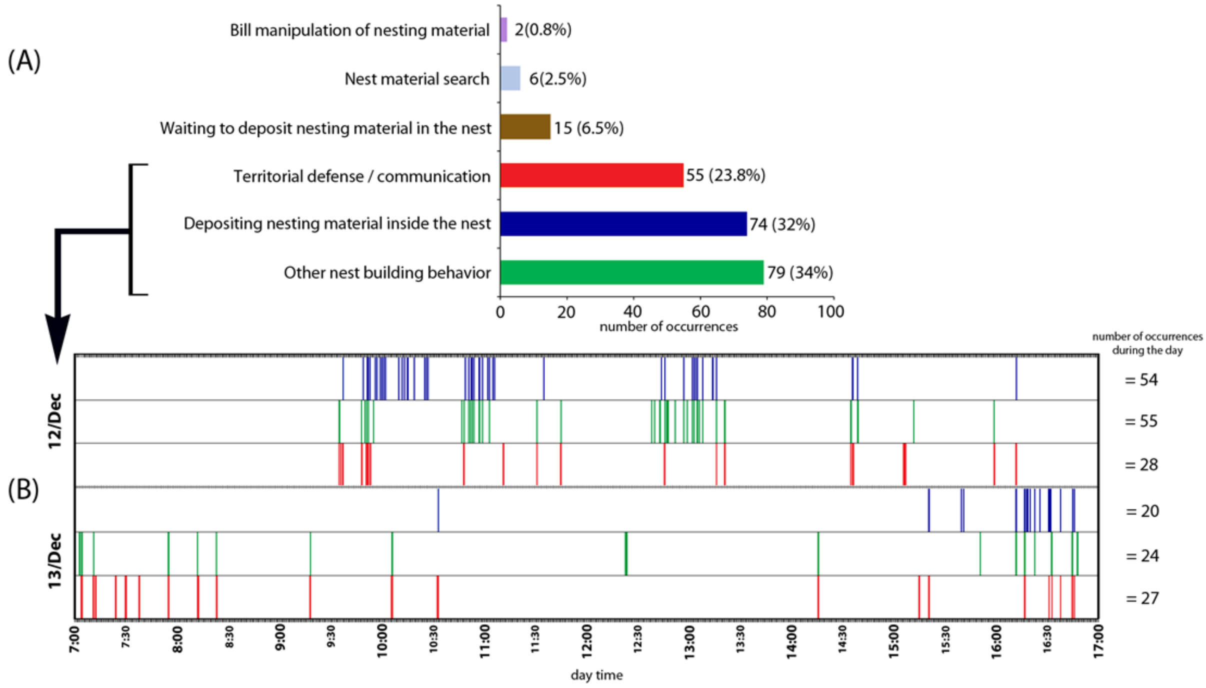


**Figure 3**. a) Six broad behavior types observed during the nesting attempts of the Southern House Wren in a helmet in the urban park Museu de Biologia Prof. Mello Leitão, in Santa Teresa municipality, Brazil. These behaviors are based on 231 complete events observed on 97 camera trap videos. b) Timeline for the three most observed behaviors on 12 and 13 December 2019. The period started when the helmet was left at the site (07:00 h) and finished when it was removed (17:00 h). Note that camera trapping was not able to precisely capture the occurrence of each behavior type (see Supplementary Material 1). This figure illustrates the effort that wrens devoted in each nesting attempt for two days.

movements we recorded were incomplete and impossible to categorize into a specific behavior type. Thus, we only used complete events (i.e., movements that suggested some functionality) performed by the birds and captured by the camera trap (i.e., started and finished within the length of the video) to assign into broad behavioral categories, regardless of which individual performed them (e.g., Alexandrino et al. 2019, Table 1). After a first round of analysis of the videos, we described six behavioral categories. Next, we counted the occurrence of each behavioral category and quantified the type of vocalization, when present, using three easily recognizable Southern House Wren vocalization types: 1) contact call— short tweets (Corral et al. 2012); 2) song — a series of high-pitched and fast notes emitted within 2–5 s (Kroodsma 1977, Platt & Ficken 1987, Corbo 2007), which we considered incomplete when abruptly interrupted; and 3) sub-song — a lower amplitude vocalization compared to song, with a lower diversity and less marked notes (Thorpe & Pilcher 1958, Platt & Ficken 1987, Sawhney et al. 2006; Figure 2). We identified the type of each vocalization using sonograms created in Raven Pro 1.6 (Center for Conservation Bioacoustics 2019). Sometimes several vocalization types were emitted during one event. We also described the type, quantity and size of the materials used to build the nest (Cristofoli & Sander 2007).

**Data analysis of online records.** We classified each nesting record based on: 1) surrounding landscape (i.e., urban, rural, or other non-human-modified landscape); 2) structure or object where the nest was; 3) type of structure (i.e., natural or human made); 4) general shape of the nest (following Simon & Pacheco 2005); 5) evidence of nest use (i.e., adults in the nest, eggs, nestlings, or fledglings); 6) signs that the breeding event was likely successful (i.e., presence of fledglings); 7) whether the structure was purposely offered by people as a nest, based on the information provided by the submitting observer (these could be nest boxes or similar objects); 8) whether the nest was on or inside a stable structure; 9) whether the structure itself was safe from human interventions that could interrupt nesting (e.g., inside a car engine, inside a boot, or in a motorcycle helmet in active use, such as our case study).

As some citizen scientists uploaded more than one picture from the same nesting event on the same online platform or in more than one platform, we discarded duplicates based on the name of the observer, the time and location of the observation, and characteristics visible on the photograph. While these events were counted only once, information from each record was considered as an indicator of breeding success of each nesting event; for instance, one picture showing nest building and another photo days after with a fledgling leaving the same nest.

## RESULTS

**Nesting attempts and behavior.** In total, the Southern House Wrens attempted nest building inside a motorcycle helmet on eight days during 19 days of monitoring (at least five days between 25 November and 10 December; and later on 11, 12, and 13 December, Supplementary Material 1). None of the attempts was successful because of the daily removal of the helmet. These wrens did not attempt nest building on 17, 18, and 19 December and did not target any other helmets in the same parking lot. We did not observe other pairs nesting nearby.

Camera trapping yielded 125 videos (76 on 12 December, 39 on 13 December, and 10 on 16 December). Among these, 108 (86.4%) captured the birds near or on the helmet, with

**Table 1.** Ethogram of Southern House Wrens during nest building in a helmet in the urban park Museu de Biologia Prof. Mello Leitão, in Santa Teresa municipality, Brazil. Note that more than one event and behavior type could be performed by the same individual in the same video. Examples of each behavior observed on the camera trap are available on YouTube with links in Appendix Table A1.

| Broad behavioral category | Event | Location of the individual | Examples of videos |
|---|---|---|---|
| Depositing nesting material inside the nest | The individual enters the helmet with nesting material in its beak and leaves the material inside the helmet | Inside the helmet | Video 04<br>Video 06<br>Video 12<br>Video 15 |
| Territorial defense / communication | The individual is looking around or at the other individual with or without vocalization | Inside and outside the helmet | Video 02<br>Video 09 |
| Other nest building behavior (e.g., observing the nest or organizing nest material) | The individual is observing the helmet (inside and outside) or adjusting the nest materials inside the helmet. Videos that started with the individual already inside the helmet are considered examples of this behavior, since the video started when the bird entered the helmet. | Inside and outside the helmet | Video 04<br>Video 09 |
| Waiting to deposit nesting material in the nest | The individual is next to the helmet with material in its beak, waiting for the other individual inside the helmet to leave, then takes the nesting material inside. | Outside the helmet | Video 04<br>Video 12 |
| Manipulating nesting material in the beak | The individual is trying to get a hold of the nesting material | Outside the helmet | Video 03<br>Video 05 |
| Searching for nesting material | The individual is on the ground looking for nesting material. This behavior was captured only a few times, when the bird passed by the camera frame, while on the ground. | Outside the helmet | Video 13 |

wrens visible in 103 videos. Five videos on 16 December captured vocalizations only, with the recording triggered by people passing by. On 12 and 13 December, 97 videos captured the wrens building the nest. From these, we distinguished 391 events, among which 231 (58.7%) were complete (a mean of 2.3 complete events per video). We used these 97 videos to classify behaviors and quantify vocalizations (Figure 3a).

Wrens started nest construction inside the helmet as soon as it appeared on site, and the pace of nest construction was similar on all observation days (Supplementary Material 1, Figure 3b). On five days, between 25 November and 10 December, these birds started nest building early in the morning, and resumed their work in the early afternoon, when the helmet was returned to the parking lot (Supplementary Material 1, Figure 3b). On 11 December, the helmet remained at the parking lot all day, and we counted 28 twigs deposited inside the helmet by 14:35 h (Figure 1b) and 40 additional twigs by 17:00 h. These 68 twigs were mostly plant material of different shapes (curved, straight, and bifurcated) and a piece of metal wire (Figure 4). The size of the twigs ranged from 2.5 to 18 cm, similar to what has been reported in the literature (Alvarez-López et al. 1984, Cristofoli & Sander 2007). In the previous attempts, BAD. also reported wire, cotton, and lumps of soil. Camera trapping captured 74 occasions when nesting material was deposited (Figure 3a), and in 42 (56.7%) of these, wrens entered the helmet without adjusting the twig in their bill (see Appendix Table A1, video 05 for an example of adjusting behavior). Each day, the shape of the nest that the wrens were building resembled the *cavity without tunnel* type, as described by Simon & Pacheco (2005) and others (Alvarez-López et al. 1984, Cristofoli & Sander 2007).

Vocalizations were recorded during 96 complete events (41.5% of the 231 complete events observed). The most frequent vocalizations were contact calls. These were emitted during all types of behaviors (Appendix Table A1, videos 04, 07, 13), mostly recorded with an individual inside the helmet (Table 2). Songs were mostly emitted from outside the helmet (e.g., the wren sitting on the helmet, Appendix Table A1, video 09) and as part of a behavior associated with territorial defense (Table 2, Appendix Table A1, videos 01, 02 and 09). Individuals emitted sub-songs mostly when they were by themselves inside the helmet, but also during nest construction, when handling nest material (Table 2), and in-between complete songs and calls, either at close proximity or further away from the helmet (Table 2, Appendix Table A1 video 02).

The three days of close monitoring (11, 12, and 13 December) revealed an intense and consistent effort invested in nest construction, in which the wrens worked continuously for up to 6 h (Supplementary Material 1), performing a rich behavioral repertoire (Figure 3).

**The relationship between wrens during nest construction.** We recorded a single individual actively building the nest slightly more times (55 of the 103 videos with birds on frame, 53.3%) than two individuals (48 videos, 46.7%). The videos showed that the individuals deposited nest material and worked on the nest following the same sequence: when one wren was inside the helmet and the other arrived with nest material, this second bird entered the helmet only after the first had left (Figure 3a, Appendix Table A1, videos 04 and 12), a behavior often accompanied by contact calls (Table 2). None of the video recordings shows both individuals inside the helmet at the same time.

We tried to quantify the total number of individuals involved in the nesting attempts in the helmet. In 10 videos, we observed agonistic interactions between two individuals, such as attack flights inside, outside, and away from the helmet (Appendix Table A1, videos 07 and 11) and one instance of physical contact between individuals (Appendix Table A1, video 06). In 12 videos, we observed two individuals close (i.e., less than 30 cm) to one another in friendly interactions, suggesting that they were mates (Appendix Table A1, video 02). On 11 December, we observed a banded bird at the helmet with a numbered metal band issued by CEMAVE, the Brazilian Centre for Bird Monitoring. This individual was probably marked during the only bird banding project nearby

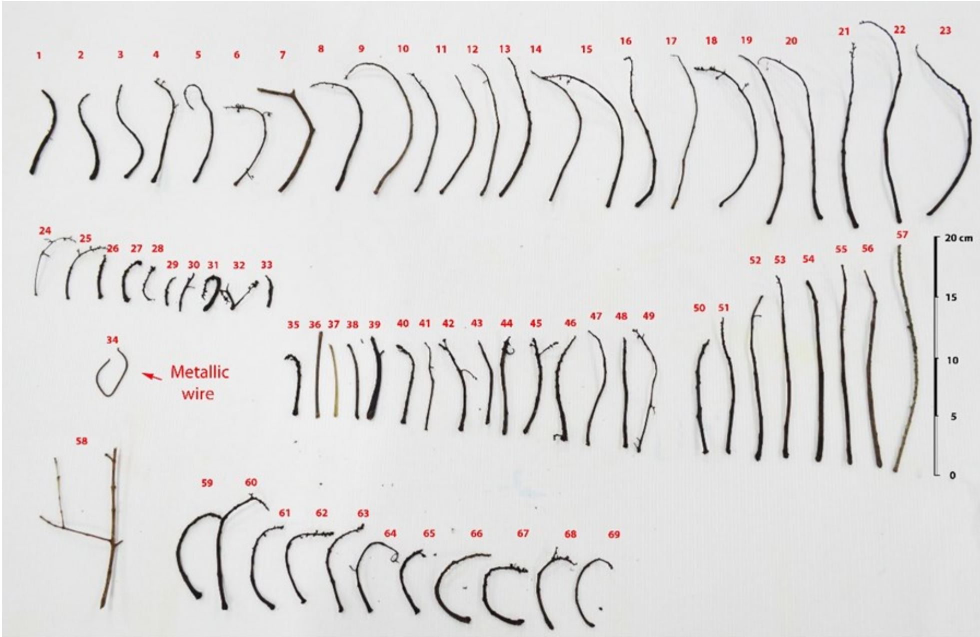


**Figure 4**. Nesting materials deposited in a helmet on 11 December 2019 by Southern House Wren, in the urban park Museu de Biologia Prof. Mello Leitão, in Santa Teresa Municipality, Brazil.

("Did I see a banded bird!?" SciStarter 2020), as there had been only one individual of this species banded in 2019 or earlier in the area (Supplementary Material 2). Therefore, at least three individuals appeared in the helmet during our observations.

**Nesting in human-made structures based on citizen science data.** In total, we found 372 Southern House Wren nest records submitted to citizen science platforms. In 98.6% of them (N = 367), we were able to identify the actual nest structure. Excluding repeated nesting events, we obtained 231 individual nesting records with information of the surrounding landscape, including 100 (43.2%) in urban ecosystems (from 04 April 2003 – 3 December 2020). These records came from 77 municipalities of 17 Brazilian federal states, with a substantially higher number of them being recorded in spring-summer (71 records between September–March) than in fall-winter (11 records between April–August), and 18 records had missing dates.

Of the 98 identifiable nests in urban areas, the most common types were *cavity* (N = 86, 87.7%) and *low cup* (N = 12, 12.2%); however, all *low cup* nests were placed inside human-made structures, in which the structure and the nest could be considered as a cavity by the bird. Also, for *cavity*-type nest records it was not possible to confirm the presence of a tunnel (as described in Simon & Pacheco 2005). Plant material (e.g., twigs or dry grass) were present in all nests forming the incubation chamber, as in the nest that we observed in the helmet.

We were able to distinguish 26 different types of nesting structures used by the Southern House Wren in 86 urban nest records. Twenty-four were human-made structures and only two were natural (Supplementary Material 3). The number of nests built on or inside structures purposely offered by humans (i.e., equivalent of a nest box) was slightly lower (N = 39, 45.3%) than those not purposely offered as nest platforms by humans (N = 47, 54.6%). Most nests (N = 71) were built on physically stable platforms and laces considered safe from human interventions (Table 3). Most (76%) of these nests had evidence of being in use by birds and nearly half (47.8%) had fledglings or other indications that the breeding event was likely successful (Supplementary Material 4). Among the seven urban nests that were found in unstable structures and places that seemed unsafe, four had signs of a successful breeding event (Table 3).

## DISCUSSION

**Southern House Wrens nesting efforts.** In our observations of a single nesting attempt, Southern House Wrens invested a large amount of effort in nest building and territory defense. Our results concur with what is known from other accounts: intraspecific competition may start during nest-site selection between members of different pairs or floating/vagrant individuals (Kendeigh 1941, Belles-Isles & Picman 1986), which demands a continuous and vigorous territory defense (e.g., vocalizations and agonistic interactions, see Figure 3).

The Southern House Wren is predominantly monogamous (Alvarez-López et al. 1984, Llambías & Fernández 2009, Brewer 2010, Llambías et al. 2019). Male and female participate in nest construction (Skutch 1953, Alvarez-López et al. 1984, Sick 1997), a process that usually takes about 20 days (Alvarez-López et al. 1984). Although we were unable to distinguish the sex and the exact number of individuals present near the helmet during our observations, we recorded instances of a pair working together but also moments of intraspecific disputes.

Although camera trapping failed to capture the number of each behavior types during the daily cycle with precision (see Supplementary Material 1, Figure 3b), our recordings show the observed individuals were actively working in reproductive activities throughout the day. On many occasions, birds flew straight into the helmet without landing near its entrance or without adjusting the twigs in their bill (Appendix Table A1, video 15), corroborating accounts from

**Table 2.** Type of vocalizations emitted by the Southern House Wrens during the nesting attempts in a motorcycle helmet in the urban park Museu de Biologia Prof. Mello Leitão, in Santa Teresa Municipality, Brazil, along with the location and the accompanying behavior. The location of the vocalizing individual is in relation to the helmet, i.e., inside the helmet, in the neck or the face opening (In); on top or next the helmet (Out); and further away from the helmet (Far). Data are from two days of camera trapping (12 and 13 December 2019).

| Vocalization type | N. obs. | Location of vocalization | | | Broad behavioral category | | | | | |
|---|---|---|---|---|---|---|---|---|---|---|
| | | In | Out | Far | Territorial defense/ communication | Other nest-building behavior | Waiting to deposit nest material | Depositing nest material | Searching for nest material | Manipulating nesting material in the beak |
| Contact call | 62 | 33 | 12 | 17 | 19 | 14 | 13 | 13 | 2 | 1 |
| Song | 50 | 10 | 23 | 17 | 47 | 2 | | 1 | | |
| Complete song | 33 | 5 | 17 | 11 | 32 | 1 | | | | |
| Incomplete song | 17 | 5 | 6 | 6 | 15 | 1 | | 1 | | |
| Sub-song | 25 | 14 | 6 | 5 | 11 | 8 | 1 | 5 | | |

the literature stating the high abilities of these wrens to perform delicate, but fast movements in a restricted space (Zuberbühler 1953, Sick 1997).

Our results suggest that vocalizations play an important role in coordinating behaviors between individuals during nest building. Songs during territorial defense have also been described in literature (Kroodsma 1977, Platt & Ficken 1987, Johnson & Kermott 1991, Corbo 2007, Grabarczyk & Gill 2019). A complete song is used to signal territory boundaries and nest location (Johnson & Kermott 1991). Unobstructed songs (e.g., from outside the helmet) and from a higher vantage point (e.g., on the handlebars of the motorcycle or on top of the helmet) improve the acoustics and the message aimed at other individuals (Marten & Marler 1977, Grabarczyk & Gill 2019). Incomplete songs are commonly associated with short-distance communication between males and females (Corbo 2007), and the observed wrens used this type of messages both inside and outside the helmet (Table 2, Appendix Table A1, videos 06 and 08). Sub-song is used by juveniles and adults (Sawhney et al. 2006, Corbo 2007). Although the reasons why the adults use this vocalization is not fully understood (Platt & Ficken 1987), we recorded sub-songs when individuals were close to one another, which suggests short-distance communication (Appendix Table A1, video 02). Sometimes, individuals emitted sub-songs when they were alone inside the helmet constructing and handling nest materials (Table 2, Appendix Table A1 videos 03 and 06). They also used it in-between complete songs and calls, from close proximity or further away from the helmet (Table 2, Appendix Table A1 video 02).

**Possible reasons why wrens nest in unsuitable human-made structures.** Most nests found in human-made structures in the citizen science platforms resemble cavities, aligning with the description of Southern House Wrens as a cavity-nesting species (Sick 1997, Brewer 2010). Cavity nesting can be a strategy to avoid certain nest predators (Belles-Isles & Picman 1986, Martin 1993, Breen et al. 2016). In an anthropogenic landscape, predation of birds that nest in or on human-made structures might be lower compared to nests in natural surroundings, as the former might be more difficult to find, reach, or be recognized as a food source by predators (Møller 2010, Stanback et al. 2013, Mainwaring 2015, Reynolds et al. 2019). Other authors have found the temperatures inside human-made structures might be more favorable for incubation (Mainwaring 2015, Batisteli et al. 2020). Thus, artificial cavities in cities that combine these benefits would be worth seeking out, even in the presence of high inter or intraspecific competition (Kendeigh 1941, Tomasevic & Marzluff 2017).

Although there are references reporting benefits for birds nesting in human-made structures, it is not well-known which structures enhance breeding performance for particular species in an urban environment. Southern House Wrens breeding in unsuitable places are reported less frequently, but recurrently (i.e., the seven records are between 2003 and 2016), suggesting that it is not a maladaptive behavior or it would have been eliminated from urban populations (Evans et al. 2010, Sol et al. 2013). Instead, our results suggest that breeding success in structures that are deemed unsuitable for nesting can be as high as in suitable structures (Table 3, see equivalent results for rural landscapes in Supplementary Material 5). Thus, a conservative answer to the question posed in the title of this article — Is it worth it? — would be 'yes, nesting in apparently unsuitable human-made structures is worth it'. However, there are some caveats to this statement.

Our study has revealed that Southern House Wrens can use a range of different human-made structures (N = 24, see Supplementary Material 3). Additional structures have been reported in Zuberbühler (1953), Skutch (1953), and Sick (1997). Based on nest-box studies as a reference for nesting in human-made structure, several variables have been reported affecting nest occupancy (i.e., type of material, shape, dimensions, orientation of the entrance, light incidence, and period of availability), which can all affect breeding success (Lambrechts et al 2010). In the case of the Southern House Wren, the environment, the site of installation, the age of the nest box and the number of times that it was previously used were also reported relevant for breeding success (Pacejka & Thompson 1996, Llambías & Fernández 2009). As our study was based on online photographs, we could not measure these or other variables. In addition, we found fewer nests in structures offered by humans for the purpose of nesting (i.e., six types of artificial nest, see Supplementary Material 3) than in structures not purposely offered, indicating that wrens might use variables in their decisions that are beyond our perception.

The only common characteristic of all nests reported was the presence of humans nearby, leading us to assume that unsuitable structures were more prone to human intervention, as they might have been under active human use (see examples in Supplementary Material 4). When bird nesting compromise human well-being (Belaire et al. 2015, Mainwaring 2015, Cox et al. 2018) people may intervene, causing negative consequences for the birds (e.g., Pruett-Jones et al.

**Table 3.** Nest records of the Southern House Wren built in suitable and unsuitable human-made structures in urban landscapes, and nesting success parameters as obtained from Wiki Aves, eBird and iNaturalist data for Brazil in 2003–2020. It was not possible to identify the stability and safety of all nests on human-made structures, therefore the percentage of use and possible breeding success are based only on classified nests. Records of empty nests without comments about nest use or breeding were excluded.

| Number of nests reported | Number of nests on or inside human-made structures | stable + safe (suitable) | | | unstable + unsafe (unsuitable) | | |
|---|---|---|---|---|---|---|---|
| | | N | Nest use | Successful breeding in progress | N | Nest use | Successful breeding in progress |
| 100 | 86 | 71 | 54 (76%) | 34 (47.8%) | 7 | 7 (100%) | 4 (57.1%) |

2007). Therefore, considering that Southern House Wrens invest a large amount of effort in nesting, if their search for nest sites leads them to unstable and unsafe substrates with high risk of human intervention (see examples in Supplementary Material 3 and 4), such as an actively used helmet, the nesting location can become an ecological trap (Mainwaring 2015).

**Take-home message – Studying urban birds through citizen science.** Published studies on Southern House Wren nesting behavior in urban environments are lacking (Cristofoli & Sander 2007), contrasting the plethora of studies of *T. aedon* in non-urban environments or that readily uses nest boxes (Llambías & Fernández 2009, Lambrechts et al 2010, Ippi et al. 2012, Carro et al. 2017). Our research added knowledge about the breeding behavior of the Southern House Wren and its natural history in an urban ecosystem. It was possible because citizen scientists contributed at different levels of the scientific process. First, our study could not have started without the strong collaboration between the owner of the helmet and professional scientists. This 'collaborative' citizen science (Shirk et al. 2012) is still a rare way of starting ornithological research in urban environments in the tropics, but should be encouraged. It can potentially lead to new discoveries about common species adapting their behavior to living in cities (Pizo 2018, Alexandrino et al. 2019, Batisteli et al. 2020). We also relied on the hundreds of nesting records provided by observers through crowdsourcing platforms. Even though the nesting attempt of the observed individuals in the helmet was unsuccessful, online data available from citizen science platforms show that wrens can successfully nest in human-made structures. As nature enthusiasts submit their data to citizen science platforms, including observations on uncommon bird behaviors, we believe citizen science data can support future studies of behavior ecology of many other common birds coexisting with humans (Barbosa et al. 2021).

Finally, please note that supplementary material and Appendix Table A1 are also included with this publication.

## ACKNOWLEDGMENTS

We thank P Prist and F Abra from ViaFAUNA for lending us the camera used in this study. We are grateful to Priscila M.P. Motta, from the municipality of Santa Teresa, who provided updated information about the region and its urban areas. R Guedes from Wiki Aves provided tabulated data, and V Balestrini, V Piacentini, FC Straube and K Del-Claro gave insightful suggestions on an earlier draft. We also thank the associate editor and a reviewer for their constructive comments. ER Alexandrino and GA Silva were funded by National Council for Scientific and Technological Development (CNPq) through the Programa de Capacitação Institucional - Ministério de Ciências, Tecnologia e Inovação (MCTI), Brazil (Process SEI 01239.000055/2019-15, PCI-DD process 302037/2021-7; PCI-DA process 302025/2021-9).

## REFERENCES

Alexandrino, ER, JA Bogoni, AB Navarro, AAA Bovo, RM Gonçalves, JD Charters, JA Domini & KMPMB Ferraz (2019) Large Terrestrial Bird Adapting Behavior in an Urbanized Zone. *Animals* 9: 351.

Alvarez-López, H, MD Hereida-Flores & MC Hernandez-Pizarro (1984) Reproduccion del cucarachero comun (*Troglodytes aedon*, Aves, Troglodytidae) en el Valle del Cauca. *Caldasia* 14: 85–123.

Barbosa, KVC, PF Develey, MC Ribeiro, & AE Jahn (2021) The contribution of citizen science to research on migratory and urban birds in Brazil. *Ornithology Research* 29: 1–11.

Batisteli, AF, LB Souza, IZ Santieff, G Gomes, TP Soares, M Pini, R Guillermo-Ferreira, MA Pizo & H Sarmento (2020) Buildings promote higher incubation temperatures and reduce nest attentiveness in a Neotropical thrush. *Ibis* 163: 79–89

Belaire, JA, LM Westphal, CJ Whelan & ES Minor (2015) Urban residents' perceptions of birds in the neighborhood: Biodiversity, cultural ecosystem services, and disservices. *The Condor: Ornithological Applications* 117: 192–202.

Belles-Isles, JC & J Picman (1986) House Wren Nest-Destroying Behavior. *The Condor* 88: 190–193.

Breen, A, LM Guillette & SD Healy (2016) What can nest-building birds teach us? *Comparative Cognition & Behavior Reviews* 11: 83–102

Brewer, D (2010) *Wrens, dippers and thrashers.* Christopher Helm Publisher, London, UK

Carro, ME, PE Llambías & GJ Fernández (2017) Mate and territory availability affect breeding dispersal and divorce in a resident Southern House Wren *Troglodytes aedon musculus* population. *Ibis* 159: 168–179.

Carvalho Filho, EPM, CEA Carvalho & GDM Carvalho (1998) Descrição da nidificação de *Micrastur semitorquatus* (Falconiformes: Falconidae) no interior de uma habitação rural, no Município de Sete Lagoas -MG. *Atualidades Ornitológicas* 86: 6.

Center for Conservation Bioacoustics (2019) *Raven Pro: Interactive Sound Analysis Software (Version 1.6.1)* [Computer software]. Ithaca, NY: The Cornell Lab of Ornithology. Available at http://ravensoundsoftware.com/ [Accessed 20 May 2020].

Corbo, MC (2007) Tratamento multimídia da variação individual do canto de *Troglodytes aedon* (Troglodytidae) na cidade de Campinas, Estado de São Paulo. M.Sc. thesis. Universidade Estadual de Campinas, Campinas, Brazil.

Corral, G, M Carro, ME & GJ Fernández (2012) Alarm calls of nesting southern house wrens (*Troglodytes musculus*). *Ornitologia Neotropical* 23: 251–260.

Cox, DT, HL Hudson, KE Plummer, GM Siriwardena, K Anderson, S Hancock, P Devine-Wright & KJ Gaston (2018) Covariation in urban birds providing cultural services or disservices and people. *Journal of Applied Ecology*, 55: 2308–2319.

Cristofoli, SI & M Sander (2007) Composição do ninho de Corruíra: *Troglodytes musculus* Naumann, 1823 (Passeriformes: Troglodytidae). *Biodiversidade Pampeana* 5: 6–8.

Evans, KL, BJ Hatchwell, M Parnell & KJ Gaston (2010) A conceptual framework for the colonization of urban areas: the blackbird *Turdus merula* as a case study. *Biological Reviews* 85: 643–667.

Grabarczyk, EE & SA Gil (2019) Anthropogenic noise masking diminishes house wren (*Troglodytes aedon*) song transmission in urban natural areas. *Bioacoustics* 29: 518–532.

iNaturalist (2021) Project Biodiversidade de Santa Teresa e INMA. Available at https://www.inaturalist.org/projects/biodiversidade-de-santa-teresa-es-e-inma [Accessed 27 July 2021].

Ippi, S, RA Vásquez, J Moreno, S Merino & CP Villavicencio (2012) Breeding biology of the southern house wren on Chiloé Island, southern Chile. *The Wilson Journal of Ornithology*, 124: 531–537.

Johnson, LS & LH Kermott (1991) The functions of song in male house wrens (*Troglodytes aedon*). *Behaviour* 116: 190–209.

Kendeigh, SC (1941) *Territorial and mating behavior of the House Wren*. University of Illinois Press, Chicago, Illinois, USA.

Kroodsma, DE (1977) Correlates of song organization among North American wrens. *American Naturalist* 111: 995–1008.

Lambrechts, MM, F Adriaensen, DR Ardia, AV Artemyev, F Atiénzar, J Bańbura, E Barba, JC Bouvier, et al. (2010) The design of artificial nestboxes for the study of secondary hole-nesting birds: a review of methodological inconsistencies and potential biases. *Acta Ornithologica*, 45: 1–26.

Llambías, PE & GJ Fernández (2009) Effects of nestboxes on the breeding biology of Southern House Wrens *Troglodytes aedon bonariae* in the southern temperate zone. *Ibis* 151: 113–121.

Llambías, PE, MM Jefferies, PS Garrido & GJ Fernandez (2019) Social Mating System Divergence Between North and South Temperate Wrens. Pp 1–20 *in* Reboreda, JC, VD Fiorini & DT Tuero (eds). *Behavioral Ecology of Neotropical Birds*. Springer, Cham, Switzerland.

Mainwaring, MC (2015) The use of man-made structures as nesting sites by birds: A review of the costs and benefits. *Journal for Nature Conservation* 25: 17–22.

MapBiomas (2020) Projeto MapBiomas – Coleção 5.0 da Série Anual de Mapas de Cobertura e Uso de Solo do Brasil. Available at https://plataforma.brasil.mapbiomas.org/ [Accessed 03 Aug 2020].

Marten, K & P Marler (1977) Sound transmission and its significance for animal vocalization. *Behavioral ecology and sociobiology* 2: 271–290.

Martin, TE (1993) Nest predation and nest sites. *BioScience* 43: 523–532.

Møller, AP (2010) The fitness benefit of association with humans: elevated success of birds breeding indoors. *Behavioral Ecology* 21: 913–918.

Muralidhar, A & S Barve (2013) Peculiar choice of nesting of Red-wattled Lapwing *Vanellus indicus* in an urban area in Mumbai, Maharashtra. *Indian Birds* 8: 6–9.

Pacejka, AJ & JC Thompson (1996) Does Removal of Old Nests from Nestboxes by Researchers Affect Mite Populations in Subsequent Nests of House Wrens? Journal of Field Ornithology. 67: 558–564.

Pacheco, JF, LF Silveira, A Aleixo, CE Agne, GA Bencke, GA Bravo, GRR Brito, M Cohn-Haft, et al. (2021). Annotated checklist of the birds of Brazil by the Brazilian Ornithological Records Committee – second edition. *Ornithology Research*, 29: 94–105

Piratelli, AJ, AG Franchin & OH Marín-Gómez (2017) Urban Conservation: Toward Bird-Friendly Cities in Latin America. Pp 143–158 *in* MacGregor-Fors I, & JF Escobar-Ibáñez, JF (eds). *Avian ecology in latin American cityscapes*. Springer, Cham, Switzerland.

Pizo, MA (2018) A Narrow-billed Woodcreeper, *Lepidocolaptes angustirostris*, nesting in a mailbox. *Ornithology Research 26*: 189–191.

Platt, ME & MS Ficken (1987) Organization of singing in house wrens. *Journal of Field Ornithology* 58: 190–197.

Prefeitura de Santa Teresa (2020). Prefeitura Municipal de Santa Teresa – Localização. Available at www.santateresa.es.gov.br [Accessed 18 April 2020].

Pruett-Jones, S, JR Newman, CM Newman, ML Avery & JR Lindsay (2007) Population viability analysis of monk parakeets in the United States and examination of alternative management strategies. *Human-Wildlife Conflicts* 1: 35–44

Remsen, JV, Jr., JI Areta, E Bonaccorso, S Claramunt, A Jaramillo, JF Pacheco, MB Robbins, FG Stiles, et al. (2020) *A classification of the bird species of South America. American Ornithological Society*. Available at http://www.museum.lsu.edu/~Remsen/SACCBaseline.htm [Accessed 11 May 2020].

Reynolds, SJ, JD Ibáñez-Álamo, P Sumasgutner & MC Mainwaring (2019) Urbanization and nest building in birds: a review of threats and opportunities. *Journal of Ornithology* 160: 841–860.

Ribeiro, S, DB Machado & C Galvão (2019) Nidificação de *Vanellus chilensis* (Charadriiformes: Charadriidae) em telhado, no município de Porto Alegre, Rio Grande do Sul. *Atualidades Ornitológicas* 211: 23.

Salles, O (1986) Alguns dados sobre a nidificação da Andorinha-Pequena-de-Casa. *Atualidades Ornitológicas* 9: 6.

Santiago-Alarcon, D & CA Delgado-V (2017) Warning! Urban Threats for Birds in Latin America. Pp 125–142 *in* MacGregor-Fors I, & JF Escobar-Ibáñez (eds). *Avian ecology in latin American cityscapes*. Springer, Cham, Switzerland.

Sawhney, MH, MC Baker & BR Bisbee (2006) Development of vocalizations in nesting and fledging house wrens in natural populations. *Bioacoustics: The International Journal of Animal Sound and its Recording* 15: 271–287.

SciStarter (2020) Did I see a banded bird? Available at https://scistarter.org/did-i-see-a-banded-bird [Accessed 17 June 2020].

Shirk, JL, HL Ballard, CC Wilderman, T Phillips, A Wiggins, R Jordan, E McCallie, M Minarchek, et al. (2012) Public participation in scientific research: a framework for deliberate design. *Ecology and Society* 17: 29.

Sick, H (1997) *Ornitologia brasileira*. Editora Nova Fronteira, Rio de Janeiro, Brazil.

Silva, JN & MN Martinelli (2011) Avifauna urbana do município de Santa Teresa, região serrana do estado do Espírito Santo, Brasil. *Atualidades Ornitológicas* 163: 63–69.

Simon, JE & S Pacheco (2005) On the standardization of nest descriptions of Neotropical birds. *Revista Brasileira de Ornitologia* 13: 143–154.

Skutch, AF (1953) Life history of the southern house wren. *The Condor* 55: 121–149.

Sol, D, O Lapiedra & C González-Lagos (2013) Behavioural adjustments for a life in the city. *Animal Behaviour* 85: 1101–1112.

Stanback, MT, JE Bartholomew, LM Bergner, EL Cline, PI Helms, PG McGovern, DM Millican & JE Roth, (2013) House wrens alter nest architecture to compensate for cavity vulnerability. *The Wilson Journal of Ornithology* 125: 174–178.

Thorpe, WH & PM Pilcher (1958) The nature and characteristics of subsong. *British birds* 51: 509–514.

Tomasevic, JA & JM Marzluff (2017) Cavity nesting birds along an urban-wildland gradient: is human facilitation structuring the bird community? *Urban ecosystems* 20: 435–448.

Viana, IR, TD Silva & JJ Zocche (2012) Nidificação de *Micrastur semitorquatus* Vieillot, 1817 (Falconiformes: Falconidae) no interior de uma habitação humana urbana no sul de Santa Catarina, Brasil. *Revista Brasileira de Biociências* 10: 171–175.

Wiki Aves (2020) A Enciclopédia das Aves do Brasil – Espécies em Santa Teresa/ES. Available at https://www.wikiaves.com.br/municipio_3204609 [Accessed 18 October 2020].

Zuberbühler, EA (1953) Dos nidos de Ratona. *El Hornero* 10: 93–094.