Habitat use and home range of a migratory bird, *Myiodynastes maculatus solitarius*, in an urban park in the Atlantic Forest, Brazil

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ABSTRACT: Detailed studies on the home range size and habitat use of a species are important for the understanding of population dynamics and density. The Southern Streaked Flycatcher (*Myiodynastes maculatus solitarius*) is a common, widely distributed austral migrant in Brazil that inhabits open areas, forest edges and urban parks. Surprisingly, very little information exists on even basic aspects of its natural history, and details about its habitat use and home range are essentially unknown. We estimated home range size and habitat selection by *M. m. solitarius* during the 2017–2018 breeding season at Parque Ecológico do Tietê, an urban park in São Paulo, Brazil. We mist-netted and banded three adult individuals, which were followed for a total of 91 h and 50 min to assess their habitat use and home range. Home range size was 5.40 ± 2.45 ha (95% kernel density) and 2.46 ± 1.70 ha (50% kernel density). We obtained 428 sight records of the three individuals, and the strata most frequently used were the canopy and mid-story, in some places with a relatively high percentage of tree cover. These individuals had a clear preference for forested areas (*n* = 408), as compared to isolated trees in open areas (*n* = 20). This study contributes to enhance our knowledge of the natural history of the species and offers important new data on various aspects related to the use of space. These results also suggest that urban green areas promote the occurrence of this species in cities, using urban parks to breed and as stopover sites during migration.

KEY-WORDS: behavior, bem-te-vi-rajado, São Paulo, Streaked Flycatcher, urbanization.

INTRODUCTION

The urbanization process may affect migratory bird species in many different ways, since they use different sites through the year for wintering, stopover and breeding (Martin & Finch 1995, Lees & Martin 2015). Moreover, annual variation in urban food resource availability may favor the permanence of resident species and negatively affect migratory species, due to interspecific competition for food and nesting sites (Leveau 2018). For this reason, the structure of urban green areas and heterogeneity of the urban matrix may influence a variety of natural history traits of these species, such as habitat use and home range size.

Home range is the area used by the individual during its daily activities, including foraging and reproduction (Burt 1943, Brown & Orians 1970, Powell 2000), and it is expected that a bird species meets its basic needs within its home range (Hutto 1985). The habitat selection in birds is a behavioral, physiological and ecological response (Cody 1985), which may result in a disproportionate use of habitat, directly influencing its survival (Hutto 1985).

However, resource availability for birds in disturbed habitats can be diminished, affecting intraspecific competition (Greenberg 1986), nest predation (Rodewald *et al.* 2011) and food availability (Kohut *et al.* 2009).

Research on habitat requirements and behavior of migratory birds has almost exclusively occurred at temperate latitudes (*e.g.*, Dilger 1956, Blake & Karr 1987, Saab 1999, Norris *et al.* 2004), such that information on even basic aspects of the natural history of most migratory birds that breed in the Neotropics is still scarce. One such species is the Streaked Flycatcher (*Myiodynastes maculatus*), which occurs throughout most of the South and Central America and includes seven subspecies. The southernmost population refers to the subspecies *M. m. solitarius*, which performs poorly-known migratory movements, breeding in southern South America and moving northwards in the fall (Cueto & Jahn 2008, del Hoyo *et al.* 2018). Plumage and vocal differences indicate that this taxon may represent a valid species (del Hoyo *et al.* 2018), inhabiting different habitat types across South America, including open second-growth, forest edge and small clearings with scattered tall trees, in rural areas or

even in urban parks (Sick 1997, del Hoyo *et al.* 2018). However, the basic natural history aspects of this species, such as habitat use and home range size, are still poorly known in both natural and urban areas.

In this study, we assessed the habitat use and estimated the home range size of *M. m. solitarius* during the breeding season in an urban park in São Paulo, Brazil. We aimed to answer three main questions: 1) What is the home range size of the species in urban parks? 2) Does habitat structure influence an individual's home range size? and 3) Does phytophysiognomy influence its foraging behavior?

METHODS

Study site

Our study was carried out at the Parque Ecológico do Tietê (hereafter PET), an urban park located between the cities of São Paulo and Guarulhos (Fig. 1). Nearly 300,000 people visit the park each year (DAEE 2019). We focused our research in São Paulo portion. The city is one of the largest and most populous cities in the world (> 12 million people), composed of > 50% urban structures (*e.g.*, buildings and impervious surfaces), embedded within the Atlantic Forest ecoregion (Muylaert *et al.* 2018).

We classified the park into three types of areas: A1) Areas formed by partially open vegetation and anthropic structures with relatively high numbers of people and cars, comprised of herbaceous, shrub, arboreous and canopy vegetation strata. The understory is composed by secondary vegetation in an initial state of regeneration, such as *Leucaena* spp., *Enterolobium* sp., *Cecropia* sp., *Handroanthus* sp., *Anadenanthera* sp., *Bombacopsis* sp., *Caesalpinia* sp., *Trema* sp., *Melia* sp., *Tipuana* sp., *Tibouchina* sp., and *Schinus* sp. In the canopy there are native species and exotics, such as *Schizolobium* sp., *Chorisia* sp., *Jacaranda* sp., and mainly *Eucalyptus* spp. and *Casuarina* spp. A2). This is a corridor attached to a small fragment of forest with vegetation that is beginning to regenerate, with herbaceous, shrub and arboreous strata present. Here, the understory is composed of reforested native, exotic and ornamental species, such as *Tibouchina* sp., *Handroanthus* sp., *Libidibia* sp., *Tipuana* sp., *Schinus* sp., *Cedrela* sp., *Anadenanthera* sp., *Melia* sp., *Casuarina* sp.*, Leucaena* sp., *Ficus* spp., *Croton* sp. and *Cecropia* sp., as well as *Alchornea triplinervia*, which is very characteristic of the shrub stratum. A3) Located in an area of the park with limited public access, this area is mainly comprised by forest with tall trees, dominated by *Eucalyptus* spp. and *Casuarina* sp.; most of the *Eucalyptus* is dry or dead (J.G.V., pers. obs.). The understory comprises a less diverse, mostly secondary
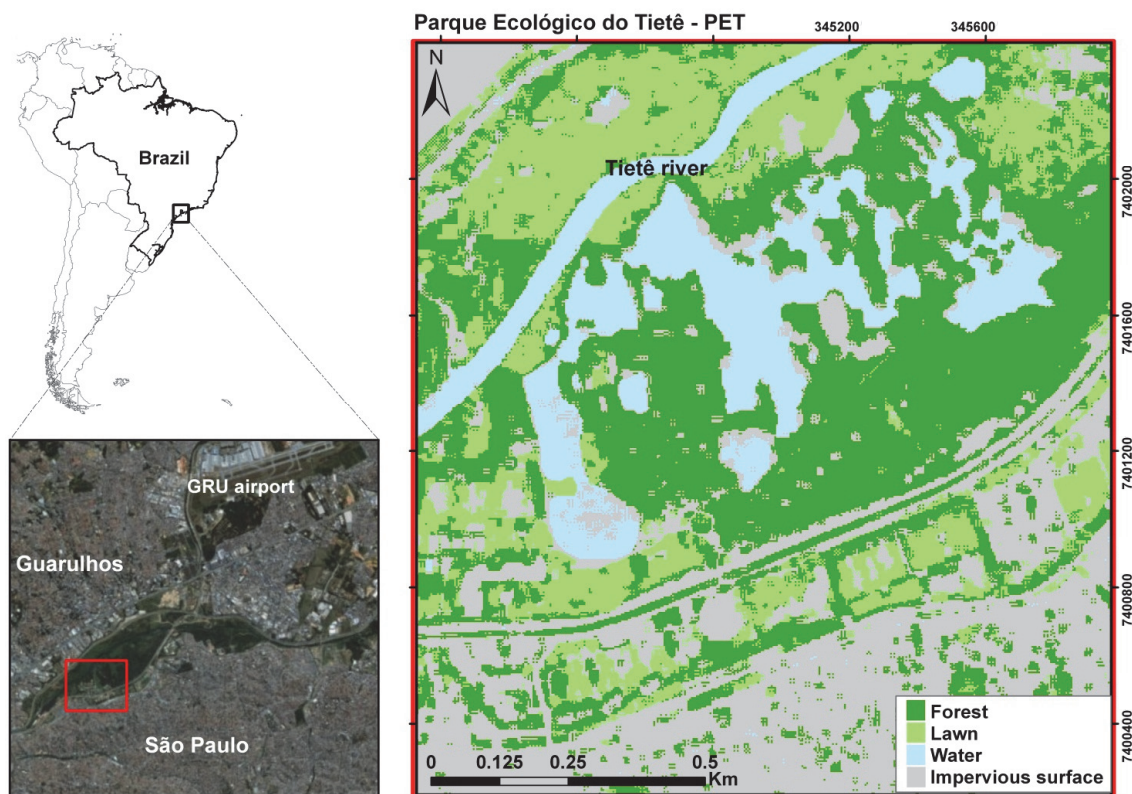
Figure 1. Map of the study area (Parque Ecológico do Tietê – PET) and its landscape components in São Paulo, Brazil.

plant community, with such species as *Anadenanthera* spp., *Melia* sp., *Leucaena* spp. and *Schinus* sp. This area is also bordered by a lake.

Fieldwork

In October 2017, we mist-netted three adult *M. m. solitarius*, which were banded with numbered and color bands for individual identification. The focal individuals were designated as A1, A2 and A3. They were followed and observed between 17 October 2017 and 31 January 2018 from 06:30 to 10:30 h, using methods described by Altmann (1974). Each individual was followed during 1 h, with its geographic coordinates registered every 10 min with the cellphone app GPS Geotracker. The following information was collected: date, initial and final time of observation, height of the vegetation stratum it was found in (high 15–20 m, middle 8–15 m and low 5–8 m), plant species it was found in, type of environment (forest or isolated tree) it was found in, height of the perch (high 15–20 m, middle 8–15 m and low 5–8 m) and stratum of foraging.

Each sampling day started with a different individual in order to minimize any time-related bias in behavioral measurements. The conspicuous vocal behavior of this species made it easy to locate, and individual identification was made using binoculars.

Analyses

Estimates of home range of *M. m. solitarius* were performed using kernel density estimation (Worton 1987), which is currently the most reliable and accurate home range estimator (Powell 2000, Jacob & Rudran 2003, Laver & Kelly 2008). We estimated 95% kernel density contours to determine the total home range and 50% kernel density of each individual, and used smoothing (h) and least square cross-validation (LSCV) (Worton 1987, Laver & Kelly 2008). Analyses were performed using the R 3.4.1 environment (R Core Team 2014) and "adehabitat" assembly packages (Calenge *et al.* 2009). The taxonomy used here follows the Brazilian Committee of Ornithological Records (Piacentini *et al.* 2015).

RESULTS

Home range

The mean home range size of the species was 5.40 ± 2.45 ha (95% kernel density) and 2.46 ± 1.70 ha (50% kernel density), described for each individual in Table 1. The largest home range, expressed as the 95% kernel contour was estimated for A1 (8.46 ha) and the smallest was for A3 (2.46 ha; Fig. 2). Home range size varied between months for all individuals, although it was different for each individual (Table 2). The three banded individuals were members of distinct social pairs, and we observed no home range overlap between the territories of each pair. Agonistic encounters were observed between individuals (*n* = 6), but only at home range boundaries.

During the observation of habitat use, we obtained 428 records of the three individuals. Across records, the high tree stratum was the most used (*n* = 247 total observations), followed by the middle (*n* = 141) and low strata (*n* = 40; Fig. 3). In general, birds were most often observed using perches in the higher strata (high = 171, middle = 177), followed by the low stratum (low = 80; Fig. 4). No individuals were seen foraging on the ground. Considering the substrates or perches selected, the A1 and A3 were similar (high = 11 and 8, respectively), (middle = 4 and 8, respectively) and (low = 5 and 5, respectively). While A2 used low perches in most capture activities (low = 33), followed by middle perches (*n* = 17). Moreover, in a total of 92 records, 84% of consumed food items were arthropods and 16% fruit. Individuals had a clear preference for forest habitats (*n* = 408) in comparison to open areas with isolated trees (*n* = 20; Fig. 5). Most

Table 1. *Myiodynastes m. solitarius* home range (ha), expressed as 50% and 95% kernel density of three individuals at Parque Ecológico do Tietê, São Paulo city, Brazil. SD = standard deviation.

ID	50%	95%
A1	1.41	8.46
A2	0.70	5.28
A3	0.35	2.46
Mean ± SD	2.46 ± 1.70	5.40 ± 2.45

Table 2. *Myiodynastes m. solitarius* home range (ha) according to 50% and 95% kernel density of three individuals of the species at Parque Ecológico do Tietê, São Paulo city, Brazil.

| Id	October		November		December	
	50%	95%	50%	95%	50%	95%
A1	0.0	1.03	1.06	5.63	2.28	9.78
A2	0.34	0.68	0.70	3.16	0.33	1.63
A3	0.68	1.70	1.06	4.93	0.65	2.61
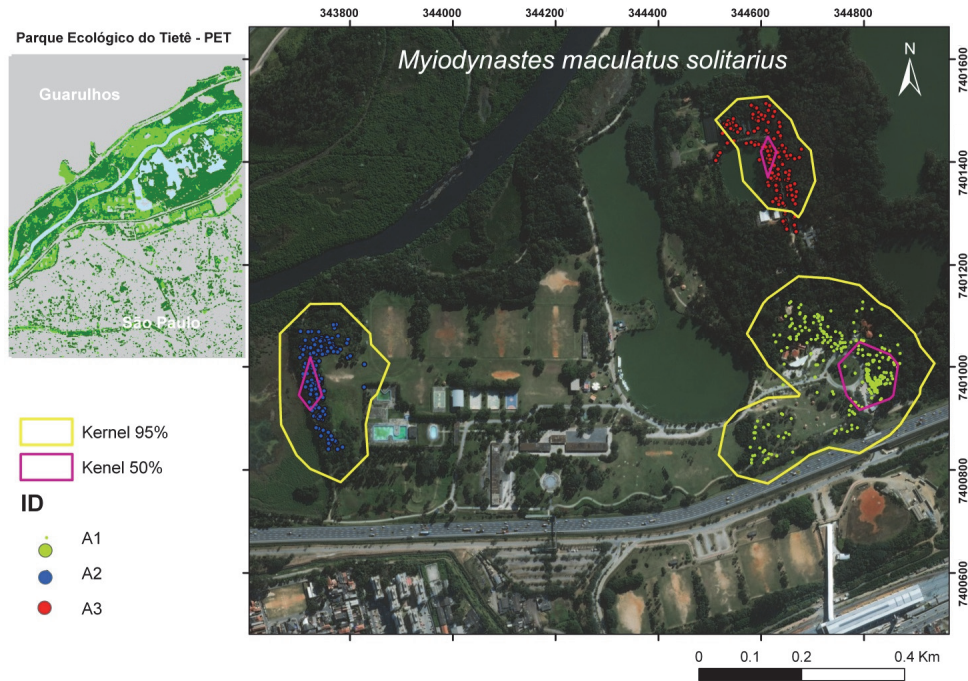
Figure 2. Points within polygons represent georeferenced fixes of observations of each bird during monitoring yellow polygons represent the 95% kernel density contours and pink polygons represent 50% kernel density, at Parque Ecológico do Tietê - SP, Brazil.
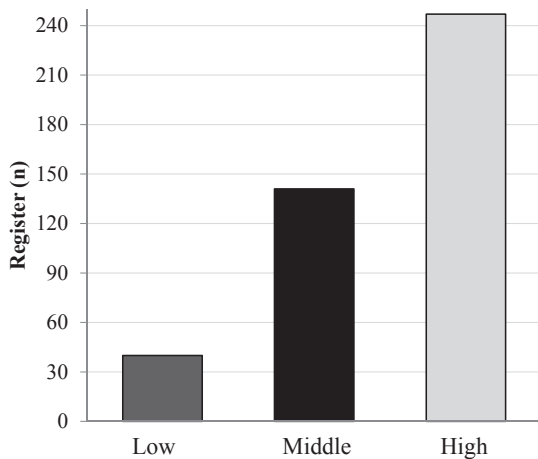
Figure 3. Tree strata used by *Myiodynastes maculatus solitarius* at Parque Ecológico do Tietê, Brazil.
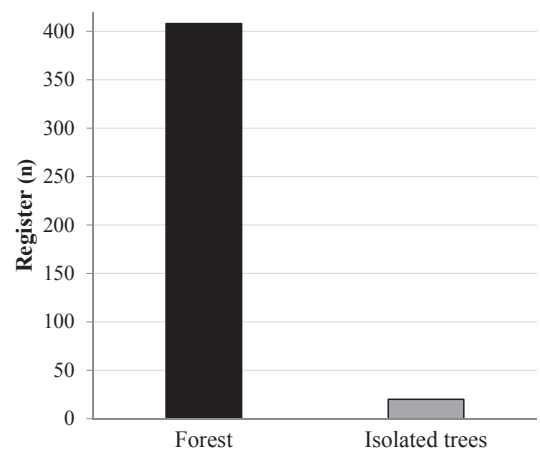
Figure 5. Habitat (forest or isolated trees) used by *Myiodynastes maculatus solitarius* at Parque Ecológico do Tietê, Brazil.
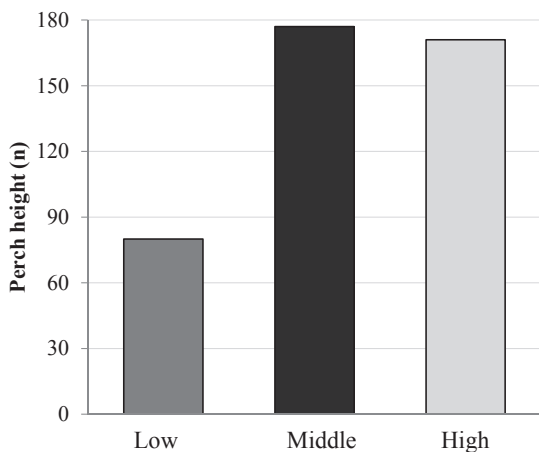
Figure 4. Height of perches used by *Myiodynastes maculatus solitarius* at Parque Ecológico do Tietê, Brazil.

observations in areas with isolated trees were of the A2 pair. The members of the pairs remained together during the entire observation period and we observed breeding activities of the A2 pair, which nested and produced three fledglings (Figs. 6A & 6B).

DISCUSSION

Information on home range size of birds in South American urban areas are scarce and have been estimated for only a few species (*e.g.*, Marantz *et al.* 2003, Hansbauer *et al.* 2008, Hilty 2011). As far as we know, this is the first assessment of the home range and habitat use of *M. m. solitarius* and our findings showed that its home range in

Figure 6. Banded *Myiodynastes maculatus solitarius* individuals at Parque Ecológico do Tietê, Brazil. (**A**) Individual A2, and (**B**) three chicks belonging to A2.

an urban area is smaller than those of most Tyrannidae species studied in natural areas (*e.g.*, Ribeiro *et al.* 2002, Lopes & Marini 2006, Jahn *et al.* 2010). Additionally, the presence of anthropogenic structures, as well as vegetation homogenization may increase the home range, since we registered *M. m. solitarius* feeding on fruits and arthropods, and in urban green areas food availability can be affected (Karr 1976, Jokimaki 1999).

Most of the work on home ranges of tyrant flycatchers in South America have been conducted in natural environments. In the rupestrian fields of Minas Gerais, the estimated home range size of *Knipolegus lophotes* (a species smaller than *M. maculatus*), is around 7 ha (Ribeiro *et al.* 2002) and in the Brazilian Cerrado, two Suiriri Flycatchers (*Suiriri suiriri* and *Suiriri affinis*) have home range sizes of up to 14.0 ha and 11.2 ha, respectively, both species using the canopy more often than other strata in Cerrado forest habitat (Lopes & Marini 2006). Another austral migrant, *Tyrannus melancholicus*, has a home range of 43.0 ± 22.6 ha for males and 45.6 ± 45.5 ha for females in the Bolivian Cerrado (Jahn *et al.* 2010), and in a mature *terra-firme* forest in the Peruvian Amazon, the austral migratory species *Legatus leucophaius* has a territory size of ~7 ha (Terborgh *et al.* 1990). Other studies have found that home ranges in urban environments are smaller than in rural or natural areas (*e.g.*, Roth-II *et al.* 2008, Chiang *et al.* 2012) and it can explain the size of home range in our results in comparison with other species of the family. Yet, the underlying mechanisms driving these patterns are still poorly understood, since a variety of interacting factors likely influence home range size in birds, including body size (Terborgh *et al.* 1990), foraging strategies (Jahn *et al.* 2010) and food availability (Newton 1979, Chiang *et al.* 2012), quality and structure of habitat (Chiang *et al.*

2012), sex and age, breeding period and time of the year (Hansbauer *et al.* 2008, Jahn *et al.* 2010).

We detected slight differences between the monitored pairs occupying different habitats, which was reflected in the size of their respective home ranges and in the way individuals used the site. The home range of A1 was more anthropized, and throughout the study this individual increased its home range from 2.31 to 6.84 ha, which is potentially due to its foraging strategy to secure sufficient food (Hansbauer *et al.* 2008). It was also possibly related to the termination of the reproductive period, after which birds are less restricted to being near the nest site (Hutto 1985). Moreover, the reduced tree cover in A1's home range may have contributed to its larger area. Here, the landscape is partially composed of lawn and buildings near the park entrance, where there is more circulation of people and cars (*i.e.*, the total area of buildings and impermeable anthropic structures occupy 0.81 ha of A1's home range). On the other hand, the landscape in A3's home range was mostly made up of forest with tall trees, including many *Eucalyptus* and dead trees, with only ~0.24 ha being composed of anthropic structures. In contrast, A2's home range was primarily composed of habitat with higher tree species richness, including native species. Moreover, in this area there are no anthropic structures and the landscape is only composed of forest intersected by a narrow trail, which potentially explains the smaller home range. A2 and its mate were also the only pair that nested and successfully reproduced, producing three fledglings (Fig. 6B).

Studies have shown that breeding birds may reduce their home range size during the egg and nestling stages (Amaral & Macedo 2003, Moraes *et al.* 2018). Our data refute those results, since in November the area occupied by A2 was larger, when the pair had nestlings and

perhaps needed to fly distantly to search for food to feed themselves and their offspring. Although large gaps in information still remain on home range size and habitat requirements of birds in urban parks, most studies to date have found a negative effect of urbanization on breeding birds in urban green spaces, in comparison to those in rural areas (*e.g.*, Bezzel 1985, Jokimaki 1999, Shustack & Rodewald 2010). For example, in an urban park in Ohio, U.S.A., the migratory flycatcher *Empidonax virescens* was negatively affected by urbanization, altering its breeding schedule, such that it nested later and had less time to breed (Shustack & Rodewald 2010). Insectivorous birds that nest in cavities, such as *M. m. solitarius*, may also be especially affected by the presence of anthropic structures, as shown in a study on two species of the family Muscicapidae: *Ficedula hypoleuca* and *Muscicapa striata* (Jokimaki 1999).

Habitat selection by insectivorous birds is usually related to their ability to find, catch and handle insect prey, activities that can be facilitated in certain types of vegetation structure (Cody 1981). *Myiodynastes m. solitarius* can be found in several different types of habitat, even in more open urban green spaces (del Hoyo *et al.* 2018). However, the individuals we observed presented a clear preference for forested habitats in our study, since nearly 95% of the records were in places with more tree cover and more complex vegetation structure. On the other hand, the species appears to be adapted to breed in a wide diversity of habitat types, including areas where *Eucalyptus* is present (Marsden *et al.* 2001, Pereira *et al.* 2015). Based on personal observations of other individuals in the study area, we noticed the constant use of *Eucalyptus* for perching, foraging or nesting by *M. m. solitarius*, normally when the tree is dead and has cavities. In the study area, *Eucalyptus* are usually taller than other tree species, allowing *M. m. solitarius* that use *Eucalyptus* to perch and move in higher strata of the vegetation. A1 and A3 showed a clear preference to perch and forage in the middle and higher strata (81% of visualizations), as is typical of the species (*e.g.*, Sick 1997). The complexity of the vegetation contributes to resource availability for birds (MacArthur & MacArthur 1961), especially for insectivorous birds (Karr 1976), with vegetation structure and food supply usually positively related (Karr 1976). In many cases, a species can adapt to characteristics of the landscape changing their behavior and home range (Chiang *et al.* 2012). Even though *M. m. solitarius* presented some plasticity in terms of its habitat use, our results suggest that the tree cover is important for the species.

The PET is certainly an important breeding habitat for this and other migratory bird species, offering resources absent in other green spaces in São Paulo (Barbosa *et al.* in prep.). Basic information about a species' ecology,

such as home range size and habitat use, provides crucial information to develop effective conservation planning (*e.g.*, Luck 2002, Oppel *et al.* 2004). Our study contributes to improving our understanding on various aspects of the natural history *M. m. solitarius* in an urban area in the Atlantic Rainforest, and highlights the importance of urban green spaces such as the Parque Ecológico do Tietê for the conservation of migratory bird species that breed in the region or stopover during migration.

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