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Source: Journal of Raptor Research, 48(2) : 142-150

Published By: Raptor Research Foundation

URL: https://doi.org/10.3356/JRR-13-00046.1

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J. Raptor Res. 48(2):142–150
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HOME RANGE AND HABITAT SELECTION BY THE TROPICAL SCREECH-OWL IN A BRAZILIAN SAVANNA

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ABSTRACT.—The Tropical Screech-Owl (*Megascops choliba*) is a small nocturnal raptor that uses a large range of habitats throughout Brazil. Although it is one of the most abundant owls in the Neotropics, nothing has been published on its spatial ecology, and information on basic natural history is scarce. We followed four radio-tagged males to estimate home-range size and habitat selection in a savanna (*cerrado*) patch in southeastern Brazil. The mean (±SD) home-range size was 51.2 (26.9) ha using the 95% minimum convex polygon (MCP) method and 80.8 (40.2) ha using the 95% fixed kernel (FK) method. The mean (±SD) core area was 22.4 (8.8) ha (65% FK). During nocturnal activities, owls preferred semi-open (*campo cerrado*) and semi-closed (*cerrado sensu stricto*) habitats and avoided open habitats (*campo sujo*). Gallery forests and patches of invasive pines were preferred for roosting during the day. The variation in size of individual home ranges may be explained by individual's breeding status and habitat structure. Home-range sizes of Tropical Screech-Owls were generally similar to those of other screech-owls in North America, and the small differences in area requirements among species may be related to body mass and habitat structure.

KEY WORDS: *Tropical Screech-Owl*; Megascops choliba; *Brazil*; cerrado; *home range*; *spatial ecology*; *Strigiformes*; *telemetry*.

ÁREA DE ACCIÓN Y SELECCIÓN DE HÁBITAT POR *MEGASCOPS CHOLIBA* EN UNA SABANA BRASILERA

RESUMEN.—*Megascops choliba* es una rapaz pequeña y nocturna que utiliza un amplio rango de hábitats por todo Brasil. Aunque es una de las lechuzas más abundantes en el Neotrópico, no se ha publicado nada acerca de su ecología espacial y la información sobre su historia natural básica es escasa. Seguimos cuatro machos marcados con transmisores de radio para estimar el tamaño del área de acción y la selección de hábitat en un parche de sabana (*cerrado*) en el sureste de Brasil. El tamaño medio del área de acción (±DE) fue de 51.2 (26.9) ha utilizando el método de 95% del polígono convexo mínimo (PCM) y 80.8 (40.2) ha utilizando el método de 95% de kernel fijo (KF). El área núcleo promedio (±DE) fue de 22.4 (8.8) ha (65% KF). Durante la actividad nocturna, las lechuzas prefirieron hábitats semi-abiertos (*campo cerrado*) y semi-cerrados (*cerrado sensu stricto*) y evitaron los hábitats abiertos (*campo sujo*). Los bosques en galería y los parches de pinos invasores fueron preferidos como sitios de descanso durante el día. La variación en el tamaño de las áreas de acción individuales puede ser explicada por el estatus reproductivo individual y por la estructura del hábitat. Los tamaños del área de acción de *M. choliba* generalmente fueron similares a aquellos de individuos de la misma especie en América del Norte, y las pequeñas diferencias en requerimientos de área entre especies pueden estar relacionadas con la masa corporal y la estructura del hábitat.

[Traducción del equipo editorial]

The Tropical Screech-Owl (*Megascops choliba*) inhabits a wide range of habitats, including open forest, forest edges, savannas with scattered trees, farmlands with woods, and urban parks. In Brazil, this species is one of the most abundant owls (Sick 1997, König and Weick 2008). Nevertheless, the spatial ecology and natural history of this species, like those of most Neotropical owls, are not well understood (Enríquez et al. 2006, König and Weick 2008). Although telemetry is an excellent tool for obtaining accurate information on individual movements, home-range sizes, and habitat use (Walls and Kenward 2007), no telemetry studies addressing these ecological characteristics of owls in Brazil have been published. Thus, to increase our understanding of

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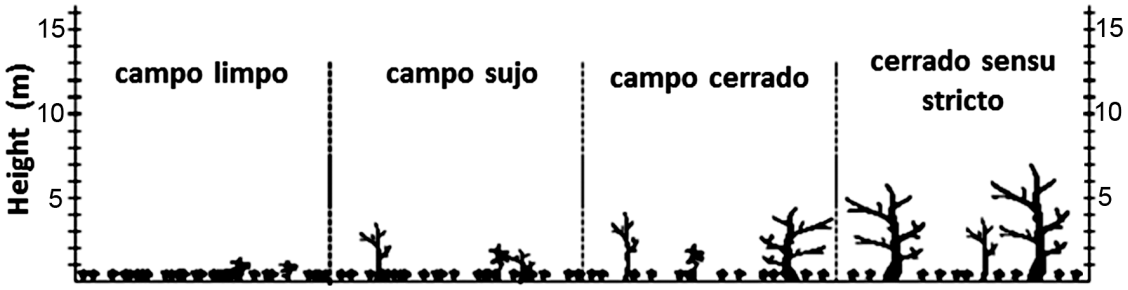


Figure 1. Schematic illustration of the vegetation gradient in *cerrado* (Brazilian savanna) physiognomies. Adapted from Coutinho (1978).

the spatial ecology of a Neotropical owl species, we radio-tracked male Tropical Screech-Owls to estimate their home-range sizes and habitat use and selection in a preserved patch of *cerrado* (Brazilian savanna) within a highly heterogeneous landscape in southeastern Brazil.

METHODS

Study Site. We studied Tropical Screech-Owls at Estação Ecológica de Itirapina (EEI), a reserve located between Itirapina and Brotas municipalities in the central state of São Paulo, southeastern Brazil (22°15′S, 47°49′W). The EEI covers approximately 2300 ha, including elevations ranging from 705 to 750 m (SEMA 2000). Average annual rainfall is 1459 mm, with a dry season occurring from April to September (23–75 mm per month) and a rainy season from October to March (120–275 mm per month; Silva 2005).

The EEI is one of the last major preserved natural savanna (*cerrado*) patches in the state of São Paulo, and in terms of vegetation density, its physiognomies range from open grasslands to closed woodland savannas (Coutinho 1978, Fig. 1) as well as gallery forests, wetlands, and small patches of invasive pine (*Pinus elliottii*; Zanchetta and Diniz 2006).

Owl Capture and Radio-tagging. Between October 2009 and February 2011, we trapped Tropical Screech-Owls using mist nets, with broadcasts of conspecific vocalizations to attract owls (Whalen and Watts 1999). For each captured owl, we collected a blood sample for sex determination (Cerit and Avanus 2007), banded the owl with one aluminum band (IBAMA 1994), weighed it with a Pesola scale, and attached a 5-g radio transmitter (model TXB-120, TELENAX, Playa del Carmen, Quintana Roo, Mexico) in a backpack configuration with waxed cotton lines (Smith and Gilbert 1981). After handling, we released the owls at the capture sites.

Telemetry Data Collection. Between October 2009 and January 2010 and, subsequently, between December 2010 and June 2011, we recorded the locations of the owls in nocturnal and diurnal periods via both triangulation and direct observation (White and Garrot 1990, Millspaugh and Marzluff 2001). We recorded all owl locations using a radio receiver (model LA12-Q, AVM Instrument Company, Colfax, California, U.S.A.), a three-element yagi antenna, a GPS device, headphones, and a compass to triangulate locations. We obtained all locations in a UTM system with a radius error of up to 8 m.

During the nocturnal period, we recorded most locations via triangulation, which entailed one researcher recording three consecutive positions and bearings, spending the shortest time possible between successive recordings (Carey et al. 1989, White and Garrot 1990). We estimated the triangulated locations in the program Locate II (Nams 2002) and corrected all bearings according to the magnetic declination in the study area during the survey periods. To assess the triangulation error, we collected simulated triangulation data, recording the locations of hidden transmitters at different known sites in EEI. Thus, using program ArcGis 9.3 (ERSI, Redlands, California, U.S.A.), we measured the distance between the real point and the triangulation-estimated point (Barros et al. 2011). The mean (±SD) error in triangulation locations was 15.3 (11.3) m (n = 10). During the night, we occasionally established visual contact with tagged owls, mainly when they were perched close to roads or trails. In this case, we recorded the exact location where the owl was perched. In diurnal periods, we recorded locations only through direct observation.

We radio-tracked each owl for 5–6 mo. Because this species is more active from the late afternoon to the first hours of the night (Braga and Motta-Junior 2009), we recorded all nocturnal locations during

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this period (1800–2300 H). To ensure temporal independence of locations, we allowed at least 40–50 min between consecutive nocturnal locations. We considered this amount of time to be sufficient for the owls to move to any site within their home range (Lair 1987, Barros et al. 2011). As the Tropical Screech-Owl tends to be inactive throughout the day (Motta-Junior 2002, König and Weick 2008), we obtained only one roosting location per day during this period.

Analysis of Telemetry Data. We calculated individual home-range sizes via the fixed kernel (FK) method (Worton 1989) using a least-squares cross-validation (Horne and Garton 2006). To compare these results with those of other surveys, we used the 95% minimum convex polygon method (Mohr 1947). We calculated the core areas (center of activity) within the home ranges using a 65% FK with a least-squares cross-validation. We performed all home-range analyses in the program Biotas 2.2 alpha (Biotas 2011). We assessed the sample sufficiency for home-range size estimation based on individual area-observation curves, using the 95% MCP method, which does not consider location density.

To assess habitat use and selection, we generated a map of the study site from a satellite image (1-m spatial resolution) from the program Google Earth (Google 2012). Then, using ArcGis 9.3 (ERSI, Redlands, California, U.S.A.), we classified all habitat types present in EEI. To ensure the accuracy of image classification, we checked all habitats in the field as references for image interpretation.

We classified the habitats as follows: wetlands (Wet): open and semi-open floodable areas with moist soil and a predominance of grasses; *campo limpo* (Cli): grasslands containing native grasses and some patches of exotic grass (*Brachiaria* spp.); *campo sujo* (Csu): grassland savannas containing native and exotic grasses with some shrubs and scattered small trees; *campo cerrado* (Cce): semi-open areas similar to Csu, but with a higher density of shrubs and small trees; *cerrado sensu stricto* (Css): semi-closed woodland savanna with spatially dense shrubs and trees; gallery forest (Gfo): closed forests near streams with dense tree vegetation and hydromorphic soils; and invasive pine (Ipi): closed and dense woodlot with a predominance of pine (*Pinus elliottii*) and with some typical *cerrado* shrubs and small trees. In EEI, Ipi is associated with wetlands that were colonized by dispersive pines from nearby pine woodlots (see Zanchetta and Diniz 2006). We classified the gradient of *cerrado* physiognomies (*campo limpo* to *cerrado sensu stricto*) according to Coutinho (1978; Fig. 1).

To test whether habitat use differed between diurnal and nocturnal periods, we used the chi-square test (χ^2) of independence, comparing the frequency of locations in each habitat for all individuals. To test habitat selection, we compared used versus available habitats within each owl home ranges using Bailey's confidence interval (Cherry 1996). To estimate habitat availability, we considered the proportional area of each habitat within each individual 100% MCP home range, which included all of the sites used and made no probabilistic assumptions (Boal et al. 2001). To identify more general habitat use patterns, we analyzed habitat selection for all the studied owls together, by summing all habitat area available (within each individual home range, MCP 100%) and all locations in the habitats used by the four owls. We estimated the individual available habitats in Biotas 2.2 alpha (Biotas 2011).

RESULTS

We captured 10 Tropical Screech-Owls: eight males (M1, M2, M3, M4, M5, M6, M7, and M8) and two females (F9 and F10). All of these individuals were ferruginous morphs, except M5 and F9, which were gray morphs. The mean (±SD) body mass of the captured owls was 113.1 (7.0) g. Although we attached radio-transmitters to all the captured owls, only four males provided sufficient data for this study due to failure of the backpack (M2, M5, and M7), failure of the transmitter (F9 and F10) and predation (M3). In the last case, we found the transmitter among Tropical Screech-Owl feathers in the soil, indicating that M3 was likely predated. Although we tracked all owls primarily during the breeding season (Sick 1997), none of them was observed using a nest throughout the study.

Home-range Size. The mean (±SD) home-range size of the four male Tropical Screech-Owls was estimated to be 51.2 (26.9) or 80.8 (40.2) ha according to 95% MCP and 95% FK, respectively (Table 1, Fig. 2). The mean (±SD) core area (FK 65%) was 22.4 (8.8) ha (Table 1). The home-range area observation curves for three individuals reached asymptotes at between 15 and 55 locations (Fig. 3). Although the home-range area observation curve for M4 did not clearly reach an asymptote, its curve tended toward stabilization; hence, we considered the data for this individual to be sufficient.

Habitat Use and Habitat Selection. In both periods (diurnal and nocturnal, $n = 335$), the Tropical

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Table 1. Home-range sizes of four male Tropical Screech-Owls at Estação Ecológica de Itirapina, southeastern Brazil (2009–2011).

				No. of Locations	Home Range (ha)		
Individual	Mass (g)	Sampling Period	Days Sampled	Total (Night + Day)	MCP 95%	FK 95%	FK 65%
M1	124	09 October 2009 to 14 April 2010	55	84 (60 + 24)	104.9	155.5	42.1
M4	118	19 November 2009 to 08 May 2010	42	88 (62 + 26)	30.3	54.0	23.7
M6	115	24 November 2009 to 08 May 2010	60	82 (56 + 26)	18.6	26.6	10.7
M8	119	27 December 2011 to 17 June 2011	37	81 (60 + 21)	50.9	85.9	21.6
Mean	**113.1**		**48.5**	**83.8 (59.5 + 24.3)**	**51.2**	**80.5**	**24.5**

Screech-Owls together mainly used *campo cerrado* (50.9%) and *campo sujo* (28.4%) habitats. When only nocturnal locations were considered ($n = 238$), we found that the same two habitats were used most by the owls (*campo cerrado*: 54.1%, *campo sujo*: 36.4%). Considering only diurnal locations ($n = 97$), the habitats that were used the most by the owls were *campo cerrado* (43.0%) and invasive pine (23.7%; Table 2). Habitat use differed significantly between diurnal and nocturnal periods ($\chi^2 = 82.159$; df = 6; $P < 0.001$).

During the nocturnal periods, the four owls selected *campo cerrado* and *cerrado sensu stricto* and avoided wetland and *campo sujo*, while during the diurnal periods, the owls selected semi-closed and closed physiognomies (*cerrado sensu stricto*, gallery forest and invasive pine) and avoided open ones (*campo sujo*; Table 2). We excluded the *campo limpo* land-cover type from our analysis because among the 335 locations recorded for all individuals in both periods, only one was situated in this land-cover type (M1, at night); thus, we did not consider *campo limpo* to be a significant habitat for the Tropical Screech-Owls in this study.

Discussion

The higher proportion of males captured in this study (80%) may reflect a greater aggressiveness of males compared to females in the presence of a conspecific intruder within the owl's territory. This behavior has been observed in other owl taxa in Europe (e.g., Finck 1990, Galeotti 1998).

In North America, the Eastern Screech-Owl (*Megascops asio*, 125–250 g; König and Weick 2008) has mean (±SD) home-range areas of 48.5 ± 5.9 ($n = 6$ adults; Belthoff et al. 1993) and 134 ± 86 ha ($n = 19$ adults; Hegdal and Colvin 1988), and uses home-range areas of 103–130 ha (Smith and Gilbert 1984). Although Gehlbach (1994) did not indicate the methodology, he reported that Eastern Screech-Owls used a 30-ha home range in rural lands and a 4–8-ha home range in urban areas. In Colorado (U.S.A.), the mean (±SD) breeding home range of the Flammulated Owl (*Psiloscops flammeolus*, 45–63 g; König and Weick 2008) was 14.2 ± 5.0 ha (Linkhart et al. 1998), and in southern Canada, Western Screech-Owls (*Megascops kennicotti*, 90–250 g; König and Weick 2008) maintained mean home ranges of 64.5 ha (Davis and Weir 2010). In the present study, the mean home-range size observed for male Tropical Screech-Owls (51.2 ha, 98 to 125 g) was similar to those of other screech-owls in North America.

Sizes of owl home ranges vary not only with the behavioral ecology of the species but also with the monitoring schedule and methods of analysis (Laver and Kelly 2008). Hence, comparisons of home-range sizes among studies are inexact. However, we suggest that the small differences in area requirements among owl species in the Americas are likely related to habitat characteristics and body mass differences (Peery 2000).

Home-range sizes of Strigiformes in the Neotropics are reported in only two published studies. One adult Puerto Rican Screech-Owl (*Megascops nudipes*) used a home range of 4.5 ha in Puerto Rico (Gannon et al. 1993), and in Guatemala, Gerhardt et al. (1994) estimated 20 ha (MCP) as the mean breeding home range for six male Mottled Owls (*Ciccaba* [formerly *Strix*] *virgata*) and 473.3 ha (MCP) for one male Black-and-white Owl (*Ciccaba* [formerly *Strix*] *nigrolineata*) in forested areas.

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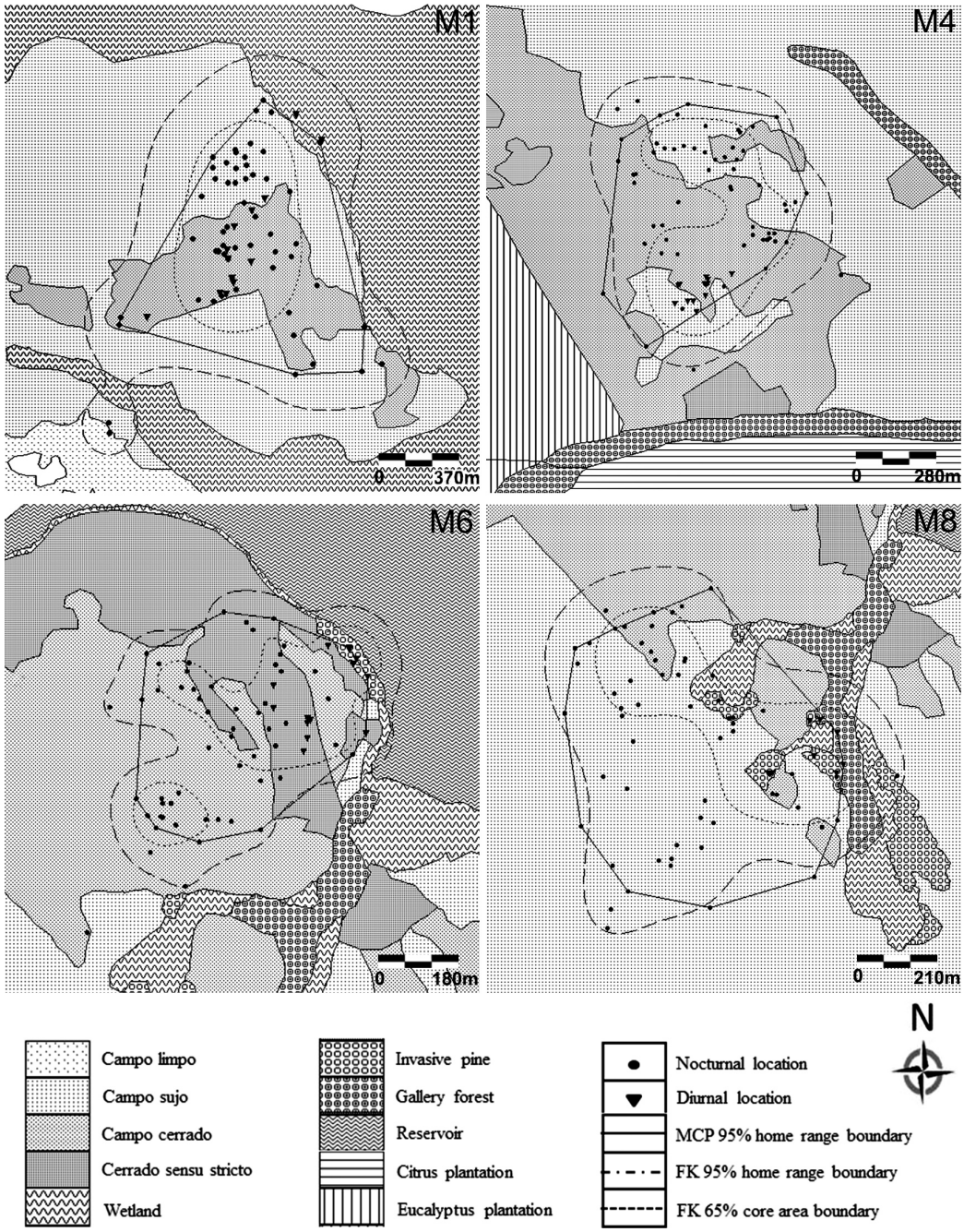


Figure 2. Home-ranges for four male (M1, M4, M6, and M8) Tropical Screech-Owls that were radio-tracked in Estação Ecológica de Itirapina, southeastern Brazil (2009–2011). The habitats *campo limpo*, *campo sujo*, *campo cerrado* and *cerrado sensu striato* represent, in this sequence, an increase in the vegetation density within *cerrado* physiognomies (see more details in Methods).

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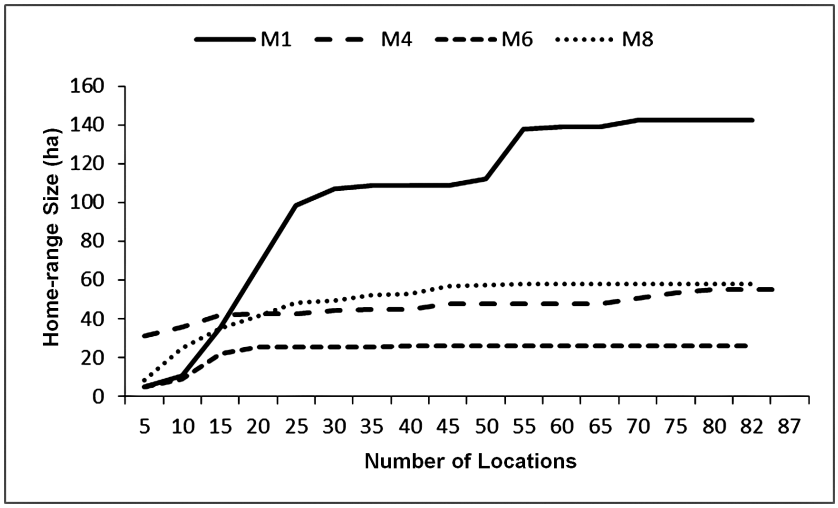


Figure 3. Area-observation curves for four male Tropical Screech-Owls that were radio-tracked in Estação Ecológica de Itirapina, southeastern Brazil (2009–2011).

Despite being considerably smaller bodied, the Tropical Screech-Owl males we studied used larger home ranges than Mottled Owl males (mean 307 g; König and Weick 2008). This difference may be related to habitat characteristics. More open habitats, such as savannas, which were the predominant habitat types used by the Tropical Screech-Owls, tend to exhibit a lower productivity per unit area and, consequently, a lower density of prey (mainly insects) than forested habitats (Silva et al. 2007). Thus, individual owls must travel larger distances searching for prey (McNaughton et al. 1989, Nilsen et al. 2005) and therefore tend to use larger home ranges than in forested habitats.

In the present study, we found that the individual home-range size varied greatly, especially for M1, which occupied an area approximately six times larger than the smallest home-range size found (M6) among the tracked individuals. This was most likely due to a combination of factors. The predominance of more-closed habitats within the home range of M6 perhaps provided a higher density of prey, which may explain why M6 exhibited the smallest home range in EEI. Furthermore, the home range of M1 included a high proportion of open habitats (Csu); thus, the large difference between the sizes of the home ranges of M1 and M6 may also be due to differences in habitat productivity within their home ranges. In addition, M1 was likely a floater. During diurnal monitoring, we did not observe M1 to be paired with a female in any of our visits to roosting sites ($n = 21$), unlike M6, which

Table 2. Habitat selection by male Tropical Screech-Owls at Estação Ecológica de Itirapina, southeastern Brazil (2009–2011). (Wet) wetlands, (Csu) *campo sujo*, (Cce) *campo cerrado*, (Css) *cerrado sensu stricto*, (Gfo) gallery forest, and (Ipi) invasive pine. (NU) not used, (+) selected, (−) avoided, (=) used according to the availability.

Habitat	Proportion of Expected Use *(Pio)*	Proportion of Observed Use *(Pi)*		Bailey's Interval for *Pi*		Selection	
		Night	Day	Night	Day	Night	Day
Wet	0.044	0.009	0.022	$0.000 \leq pi \leq 0.038$	$0.000 \leq pi \leq 0.091$	−	=
Csu	0.520	0.364	0.086	$0.283 \leq pi \leq 0.448$	$0.025 \leq pi \leq 0.183$	−	−
Cce	0.391	0.541	0.430	$0.455 \leq pi \leq 0.625$	$0.295 \leq pi \leq 0.560$	+	=
Css	0.028	0.065	0.161	$0.029 \leq pi \leq 0.117$	$0.074 \leq pi \leq 0.276$	+	+
Gfo	0.008	0.000	0.065	$0.000 \leq pi \leq 0.021$	$0.014 \leq pi \leq 0.155$	NU	+
Ipi	0.009	0.017	0.237	$0.002 \leq pi \leq 0.052$	$0.130 \leq pi \leq 0.361$	=	+
Total	**1.000**	**1.000**	**1.000**				

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was paired on 72% ($n = 23$) of our visits to its roosting sites (F.M. Barros unpubl. data). In general, unpaired individuals do not have stable territories and display irregular movements throughout their home ranges (Klatt and Ritchison 1994, Hunt 1998, Campioni et al. 2010). Thus, to some extent, we suggest that the absence of pairing may have led to the M1's larger home-range.

Habitat Use and Habitat Selection. In general, during the night, most owls hunt, rest, engage in social interactions, and defend territories (Boxall and Lein 1989, Sick 1997, König and Weick 2008, Campioni et al. 2010), whereas during the day, nocturnal owls (such as Tropical Screech-Owls) only rest (König and Weick 2008), although some species may sometimes hunt opportunistically (Sovern et al. 1994, Herter et al. 2002). In the present study, the habitats were not used equally by the owls in the diurnal and nocturnal periods, suggesting that their habitat use is modulated by the activities performed during each period. In the early evening, owls typically move from roost sites to hunting areas, which may be far apart (König and Weick 2008), and this may also be the case for Tropical Screech-Owls in EEI. Except for M1, which seemed to be a non-territorial floater, all the owls appeared to roost at determined sites and hunt at other sites (Fig. 2).

Nocturnal period. Tropical Screech-Owls selected semi-open habitats and avoided open habitats during nocturnal activities, as suggested in other studies (Braga 2006, Motta-Junior 2006, König and Weick 2008). In the same study site (EEI), using playback techniques, Braga (2006) also observed a pronounced use of and preference for semi-open (*campo cerrado*) to semi-closed (*cerrado sensu stricto*) physiognomies among Tropical Screech-Owls. The owls' responses to playbacks of conspecific vocalizations primarily indicate sites (and habitats) where owls defend their territories, which may not necessarily be the same habitats the owls use for hunting, social interactions, or any other important nocturnal activity. In Europe, the areas defended against intruders (territory) by the Little Owl (*Athene noctua*) were larger and showed less seasonal variation than the undefended areas used for hunting and all other nocturnal activities (Finck 1990).

Diurnal period. We found that the Tropical Screech-Owl appears to use and prefer habitats with dense and closed vegetation for roosting. The high frequency of use of semi-open habitat (*campo cerrado*) during the day found for M1 and M4 was most likely due to a lack of availability of denser and more closed habitats in their home-range areas (Fig. 2).

In different regions of the world, especially in temperate regions, nocturnal owl species tend to roost at sites with a higher density of vegetation during the day (Roth and Powers 1979, Grove 1985, Young et al. 1998, Churchill et al. 2000). This behavior may be a strategy to minimize predation risk (Hayward and Garton 1984, Grove 1985, Churchill et al. 2000). This explanation may also hold true for the Tropical Screech-Owl in EEI, because although this species has cryptic plumage, it may still be vulnerable to predation by other larger raptors, as has been reported for several other small owls in Europe (Mikkola 1983).

ACKNOWLEDGMENTS

We would like to thank CAPES (Conselho de Aperfeiçoamento de Pessoal de Nível Superior) for the scholarship provided to FMB, Idea Wild for the donated radiotransmitters, IF/SP (Instituto Florestal do Estado de São Paulo) for the license to access EEI and CEMAVE/ICMBio (Centro Nacional de Pesquisa e Conservação de Aves Silvestres) for supplying bands. We are also especially grateful for the help of the EEI staff and all fieldwork assistants.

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Received 26 June 2013; accepted 2 January 2014
Associate Editor: Jessi L. Brown

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