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SEASONAL HOME RANGE SIZE OF TROPICAL KINGBIRD (*TYRANNUS MELANCHOLICUS*) IN THE SOUTHERN AMAZON BASIN

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Resumen. – El tamaño del ámbito hogareño entre temporadas de *Tyrannus melancholicus* en el sur de la Cuenca Amazónica. – El conocimiento de cómo el tamaño del ámbito hogareño varía entre temporadas es útil para entender como las aves responden a cambios en los niveles de recursos. Sin embargo, los patrones entre temporadas del tamaño del ámbito hogareño de la mayoría de las aves Neotropicales son todavía poco conocidos. Documentamos la ubicación de individuos de *Tyrannus melancholicus* durante cuatro años en un sitio en el sur de la Cuenca Amazónica compuesto por cerrado, bosque húmedo y campo de pasto para ganado. Aunque los *T. melancholicus* tuvieron ámbitos hogareños más pequeños en la época no-reproductiva que en la época reproductiva, las diferencias en el tamaño del ámbito hogareño entre épocas no fueron significativas. Tampoco encontramos diferencias significativas en el promedio del tamaño del ámbito hogareño entre machos (43.0 ± 22.6 ha) y hembras (45.6 ± 45.5 ha). Seguimos a nueve *T. melancholicus* mediante el uso de la radio telemetría y comparamos el ámbito hogareño de estos individuos a los de individuos detectados solo mediante la observación de anillos de color. No encontramos diferencias significativas en el promedio del tamaño del ámbito hogareño entre individuos detectados con radio telemetría (41.8 ± 24.0 ha) e individuos detectados con anillos de color (43.4 ± 36.3 ha), cual sugiere que estos dos métodos para estimar el tamaño del ámbito hogareño son aproximadamente equivalentes.

Abstract. – Understanding how home range size varies across seasons can provide insights into how birds respond to changes in resource levels. Yet, seasonal variation in home range size of most Neotropical birds is poorly understood. We recorded locations of color-banded Tropical Kingbirds during four years at a site comprised of cerrado woodland, humid forest, and cattle pasture in the southern Amazon Basin. We found no significant difference in the mean home range size of males (43.0 ± 22.6 ha) and females (45.6 ± 45.5 ha). Although kingbirds had smaller home ranges in the non-breeding season than in the breeding season, differences in home range size were not significant between seasons. We radio-tracked nine kingbirds and compared their home range size to that of color-banded birds without radio transmitters. We found no significant difference in the mean home range size of kingbirds determined by telemetry data (41.8 ± 24.0 ha) and those determined by observations of color-banded individuals (43.4 ± 36.3 ha), suggesting that both methods of estimating home range size are roughly equivalent. *Accepted 20 November 2009.*

Key words: Bolivia, cerrado, color-banding, dispersal, radio telemetry, seasonality, Tropical Kingbird, *Tyrannus melancholicus*.

INTRODUCTION

A home range is the area normally occupied by an individual on a daily basis to meet its needs, including foraging and reproduction (Burt 1943). Because these needs as well as the abundance of resources are likely to vary seasonally, the size of a home range is likely to change seasonally. Documenting seasonal shifts in home range size is therefore a way to understand how birds respond to seasonal resources. Likewise, age- and sex-related differences in home range size between individuals yield insights into intraspecific variation in ecology and behavior. Yet, little is known about home ranges of most Neotropical bird species.

One of the most common bird species in many regions of the Neotropics is the Tropical Kingbird (*Tyrannus melancholicus*). In the southern Amazon Basin, Tropical Kingbirds are common in the Cerrado, a threatened biome endemic to central South America that includes wooded grasslands, gallery forests, and other habitat types (Ratter *et al.* 1997).

We studied the home range size and habitat occupancy of Tropical Kingbirds (hereafter "kingbirds") at a site in the southern Amazon Basin that is characterized by a strong wet-dry seasonality. We focused on three questions: 1) What is the home range size of kingbird males and females? 2) Do kingbirds occupy home ranges of different sizes between breeding and non-breeding seasons? And, 3) Is there a difference in estimates of home range size when using radio telemetry vs. re-sightings of color-banded individuals? Color banding is an alternative to radio telemetry for tracking the location and behavior of individual birds. Yet, because color bands have a much smaller detection area (i.e., the distance at which they can be identified with binoculars) than radio transmitters (i.e., the distance at which a radio signal can be detected), the accuracy of data on home range size derived from studies that use color bands is questionable and the difference in accuracy between the two methods is still poorly understood.

METHODS

We conducted the study at Caparú Biological Station (CBS), located in the Department of Santa Cruz, Bolivia (14°49'S, 61°10'W, 170 m a.s.l.). The principal habitats are humid forest, cerrado woodland, the edge between these two habitats, and cattle pasture for cattle grazing (Fig. 1). Cerrado woodland (hereafter "cerrado") is comprised of a grassy ground layer and a sparse woody layer 4–6 m high, primarily comprised of *Curatella americana* (Dilleniaceae).

We recorded daily rainfall from February 2005 to August 2007. Daily mean rainfall was 6.3 mm (± 13.6 SD) from mid-September to mid-February, which represents the kingbird's breeding season (hereafter, the "breeding season"). Daily mean rainfall for the rest of the year (hereafter, the "non-breeding season") was 2.9 mm (± 9.3 SD).

We captured 449 kingbirds from October 2004 to July 2007 using nylon and polyester mist nets (12 m and 18 m x 2.6 m, 36 mm and 38 mm mesh size). Adult kingbirds were captured throughout the study site by placing a net and a model of a common nest predator at the site (a stuffed Purplish Jay, *Cyanocorax cyanomelas*) near a nest with nestlings. We also captured kingbirds at ponds where they bathed. Kingbirds, including nestlings, were banded with a numbered aluminum band and up to three celluloid color bands in unique color combinations. We estimated age (through skull ossification and juvenal plumage; Ralph *et al.* 1993) and determined sex using primary feather notch shape (Pyle 1997). We defined adults as individuals at least one year old, with the year beginning on 1

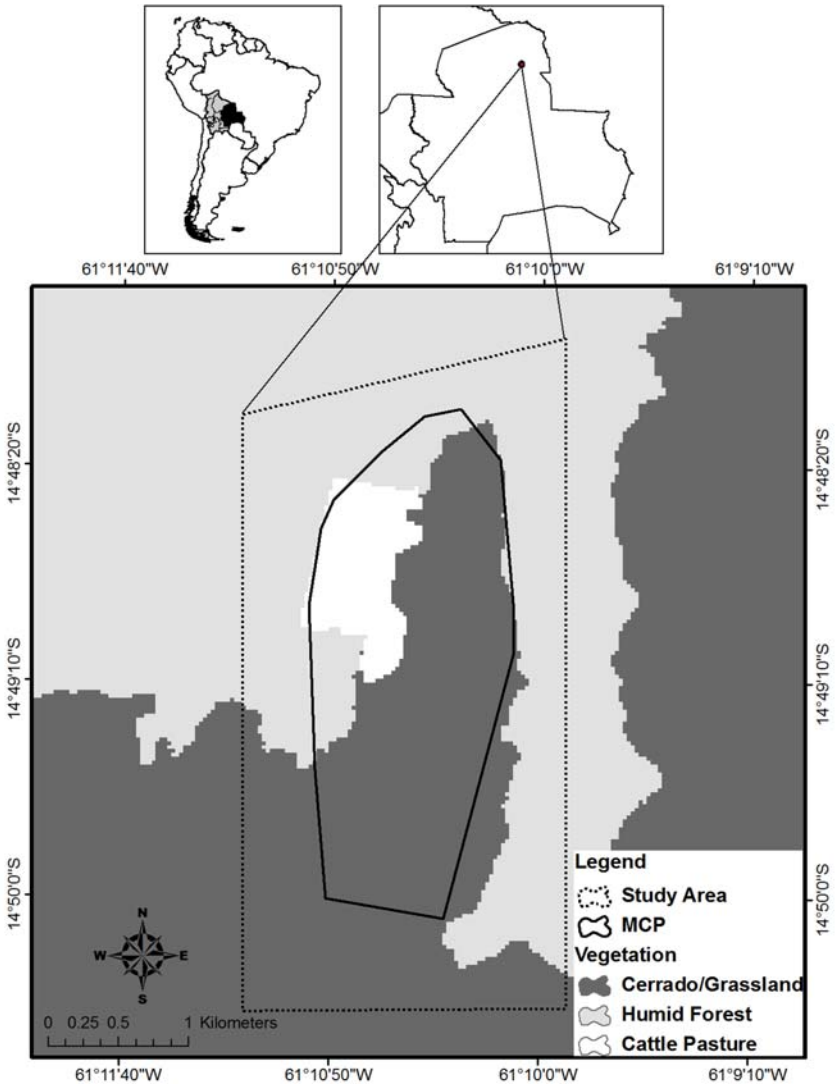

FIG. 1. Map of the study site. The country of Bolivia with its political departments is depicted in the top left diagram. The black polygon within Bolivia is the department of Santa Cruz, within which the study site is located (top right diagram). The bottom diagram depicts the study site, with the 95% Minimum Convex Polygon home range of all kingbirds, combined.

September and ending 31 August of the following year.

We divided the study site, which has a total area of approximately 900 ha, into 23 sampling plots and methodically searched the entire area of each plot for banded kingbirds by slowly walking through the plot in a zigzag pattern. We visited most plots at least monthly from February 2005 to August 2007, except for June-September 2005 (when we

were not at the site). In addition, we searched for banded kingbirds from 28 January–12 February, 2–19 March, and 15–27 June 2008. When a color-banded kingbird was observed, we geo-referenced its location using a Garmin GPS 76 receiver and noted the date, time, and color band combination.

From January–July 2007, we radio-tracked kingbirds by attaching backpack radio transmitters (American Wildlife Enterprises) to 20 kingbirds, using methods described by Rappole & Tipton (1991). Transmitters weighed 2.3 g and had a whip antenna that projected over the bird's tail. We used an R410 scanning receiver (Advanced Telemetry Systems, Inc.) and a 4 element Yagi antenna (Cushcraft Corp.) to locate the birds, 2–3 times per week. Their locations were geo-referenced using a Garmin GPS 76 receiver.

We created a 95% Minimum Convex Polygon (MCP) and a 50% Fixed-kernel home range (FKH) for individuals we geo-referenced on at least ten occasions on separate days. For seasonal comparisons, we analyzed results from kingbirds with at least four geo-referenced locations per season. We used The Animal Movement program (Hooge & Eichenlaub 1997), an extension of ArcView 3.0 (ESRI), to create home range polygons.

RESULTS

We observed 210 color-banded kingbirds at least once during the study. We geo-referenced 29 kingbirds at least ten times, based on color band observations. For these, we documented a mean of 16 (± 7.0 SD) locations across the four years of the study. We present results from adults only, since we did not have a sufficient sample of juveniles for statistical analyses. The mean MCP home range size of males (43.0 ± 22.6 ha, N = 9) did not differ from that of females (45.6 ± 45.5 ha, N = 15; Mann-Whitney $U = 57$, $P = 0.56$). Similarly, there were no significant differences between males (7.9 ± 5.1 ha) and females (8.9 ± 6.7 ha) in the mean FKH size (Mann-Whitney $U = 65.0$, $P = 0.91$).

We documented seasonal patterns based on observations of color bands for seven males and nine females. We geo-referenced a mean of 9 (± 4.8 SD) locations per kingbird in the breeding season and 7 (± 4.4 SD) locations in the non-breeding season. Both sexes generally tended to occupy larger areas in the breeding season (Fig. 2). However, the difference in mean MCP home range size between seasons of male kingbirds was not significant (Wilcoxon $Z = -1.01$, $P = 0.31$). Likewise, the mean FKH size did not differ for males between seasons (Wilcoxon $Z = -0.17$, $P = 0.87$). A similar pattern held for females between seasons (Wilcoxon $Z = -1.13$, $P = 0.26$ for MCP; Wilcoxon $Z = -0.06$, $P = 0.95$ for FKH). We did not have a sufficient sample size to compare home range sizes between sexes within seasons.

Of the 20 kingbirds that received radio transmitters, we were able to collect sufficient data to calculate home range size for nine individuals, which were all adults. We documented a mean of 24 (± 14.0 SD) locations for each of these radio-tagged kingbirds. There was no significant difference in the MCP home range size between radio-tagged kingbirds (mean: 41.8 ± 24.0 ha) and color-banded kingbirds (43.4 ± 36.3 ha; Mann-Whitney $U = 123$, $P = 0.81$), or in the mean FKH size, which was 10.4 ha (± 7.5) for radio-tagged kingbirds and 8.6 ha (± 6.6) for color-banded kingbirds (Mann-Whitney $U = 111$, $P = 0.52$).

DISCUSSION

Our results indicate that male and female kingbirds at our study site hold relatively constant home range sizes throughout the year. Additionally, data from radio telemetry and color band observations produced similar

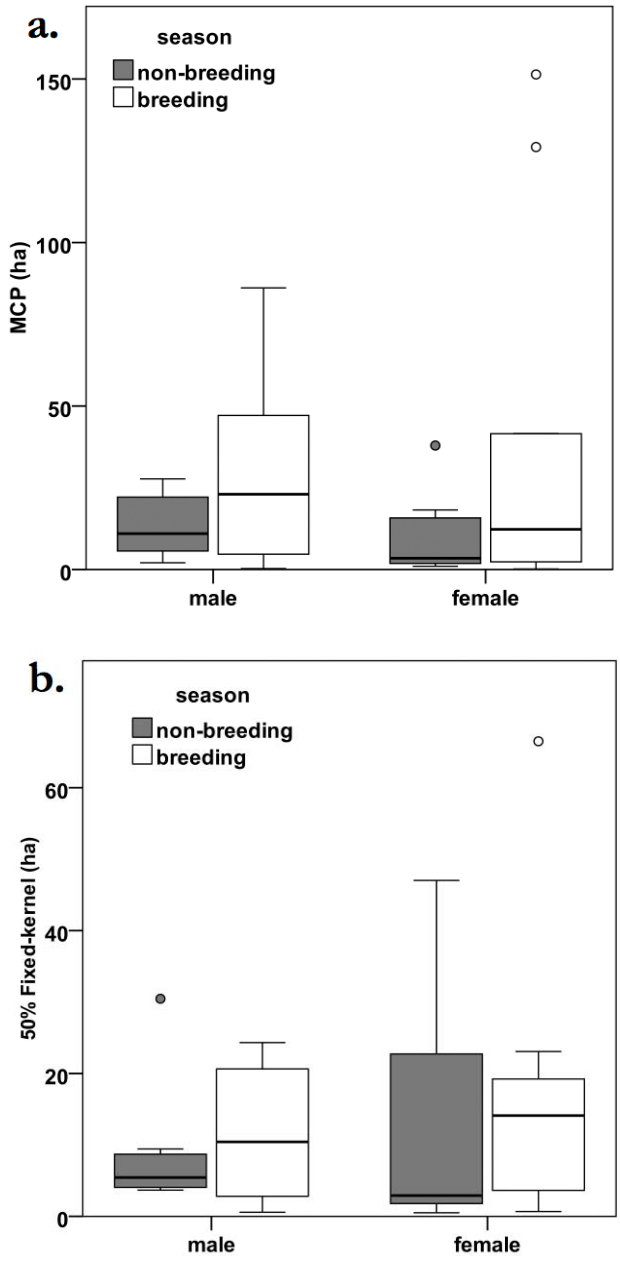

FIG. 2. Box-and-whisker diagrams of home range sizes for male and female Tropical Kingbirds at Caparú Biological Station calculated as, a) 95% Minimum Convex Polygon, and b) 50% Fixed-kernel home range. Rectangles depict the range of the first to third quartiles and the dark horizontal line within each rectangle depicts the median. Lines from each rectangle extend to the largest and smallest values, and circles outside of rectangles represent outliers.

results in terms of estimating home range size.

The mean home range of the kingbirds at CBS is generally larger than that of most other passerines whose home ranges have been studied in tropical South America. Stouffer (2007) found that Rufous-capped Antthrush (*Formicarius colma*), an understory species, occupies a territory of less than 7 ha (measured as an MCP). Most of the other understory passerines in that study had territory sizes smaller than 20 ha. In a forest fragment in Brazil, Duca *et al.* (2006) found that the home range sizes of three species of antbirds were less than 2 ha, measured as an MCP. Esteves-Lopes & Marini (2006) found that mean home range sizes of two *Suiriri* flycatcher species in the Brazilian Cerrado were 11–14 ha, and Alves (1990) found that White-banded Tanagers (*Neothraupis fasciata*) held a home range of 4.3 ha (MCP) in cerrado.

The relatively large home range of kingbirds at CBS, which primarily occupy cerrado habitat (Fig. 1), is likely due in part to their large body size relative to the species mentioned above. Indeed, a larger passerine of the cerrado, Curl-crested Jay (*Cyanocorax cristatellus*), can have home ranges > 172 ha (Amaral & Macedo 2003). Terborgh *et al.* (1990) found that home range sizes at a site in Peru were strongly correlated to body size, with larger species holding larger territories. The relatively large home range of kingbirds may also be explained by foraging strategy. Kingbirds typically sally after flying insects (Fitzpatrick 1980, Cintra 1997), which they can chase for > 50 m (AJ pers. obs.), such that they are highly mobile across the relatively open cerrado landscape. Additionally, given the outliers towards the upper end of home range size for both males and females (Fig. 2), some kingbirds in the population may be floaters rather than holders of well-defined territories. Indeed, the home ranges of most kingbirds overlap, in some cases extensively (up to 50–70% of the home range of some individuals). This is especially true for those kingbirds with larger home ranges (> 15 ha).

We found that home range sizes of males and females were not significantly different, which is not surprising given that both males and females participate in nest guarding and feeding of nestlings on territories that they share with each other (pers. obs.). In species with a different mating system (e.g., lekking species), home range size is more likely to vary between sexes and seasons. For example, in the Brazilian Atlantic Rainforest, Blue Manakin (*Chiroxiphia caudata*) males tend to have temporally stable home ranges, while home range size of females varies over time, possibly because females are involved in lek visitation during one period but at other times are focused on raising young (Hansbauer *et al.* 2008).

Rainfall in the breeding season is approximately double that in the non-breeding season at our study site. Pronounced wet and dry seasons are typical of Cerrado, which has a correspondingly strong seasonal pattern in the flowering and fruiting of plants (Batalha & Martins 2004) and in the abundance of insects that comprise the kingbird's diet (Pinheiro *et al.* 2002; Jahn 2009). Despite this strong seasonality, home range sizes of both male and female kingbirds did not differ between seasons (nor did we detect significant seasonal change in the location of home ranges, unpubl. data), although there was a tendency for home ranges to be larger during the breeding (wet) season (Fig. 2). Likewise, Duca *et al.* (2006) found that three antbird species had similar territory sizes between the breeding and non-breeding seasons in a forest fragment in Brazil. However, Hansbauer *et al.* (2008) found significant differences in female Blue Manakin home range sizes between seasons, with breeding females holding significantly smaller home ranges in the wet season

than in the dry season. In the African tropics, Brandt & Cresswell (2008) found that Rock Firefinches (*Lagonosticta sanguinodorsalis*) held larger territories in the dry season than in the wet season, likely due to trips by the birds to water sources during the dry season.

The lack of significant seasonal variation in kingbird home range size is surprising given that among species home range size is typically correlated with resource abundance (e.g., Gass 1979), and food resource abundance for kingbirds is much lower in the dry season than in the wet season (Jahn 2009). That home range size tended to be larger in the breeding season is unexpected, since movements in the breeding season should be more limited due to nesting activities (e.g., nest defense and nestling feeding). A factor that could in part be driving this pattern may be greater movement early in the breeding season due to competition for mates or territories. Larger sample sizes within or between sexes and seasons would have yielded greater statistical power but because home range sizes were similar and *P*-values large, we are confident that results based upon larger sample sizes would be similar.

Lack of seasonal variation in home range size in kingbirds may be at least partially explained by their feeding strategy. Unlike birds that glean insects from leaves, kingbirds and other species that feed on flying insects likely do not suppress the abundance of their insect prey in the area where they are feeding (Fitzpatrick 1981). Therefore, unlike leaf gleaners, kingbirds may not have to frequently move locations in search of higher insect abundances - a larger home range size in the dry season (i.e., when food is less available) would not necessarily offer them more foraging opportunities.

We found no significant difference in home range size between kingbirds detected through color band re-sighting and those detected through radio telemetry, suggesting that estimating home range size by re-sighting color bands is as accurate as doing so through radio telemetry. We caution, however, that this conclusion may not hold for species that inhabit denser habitat than the relatively open Cerrado, or for species that forage in foliage, since the detection area of color-banded individuals would be much reduced for such species.

Further research on how tropical birds use space throughout the year will contribute to the information necessary to understand the proximate mechanisms determining the distributions and movements of birds at those latitudes. Our ability to develop effective conservation plans for threatened species inhabiting rapidly disappearing ecosystems, such as South America's Cerrado (e.g., Sharp-tailed Grass-Tyrant, *Culicivora caudacuta*), would be greatly enhanced with information on home range size and habitat use throughout year.

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