

Territory size of the flavescent warbler, *Basileuterus flaveolus* (Passeriformes, Emberizidae), in a forest fragment in Southeastern Brazil

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Abstract

Factors determining territory size of Neotropical birds are still poorly studied. However, it has been pointed out that it varies according to resource availability. Here, we estimated territory size of the flavescent warbler (*Basileuterus flaveolus*) and evaluated its correlation with arthropod biomass. We conducted this study at a 19.3 ha grid inside a 50 ha forest fragment, in southeastern Brazil. Territory sizes were small, and did not vary significantly among seasons. Eight territories were recorded during the breeding season of 1998, with a mean size of 2.0 ± 0.6 ha. In six of the eight territories, males were paired. During the non-breeding season of 1999, the mean territory size was 2.2 ± 0.9 ha and in the breeding season of 1999, it was of 1.9 ± 0.8 ha. Territory sizes were not correlated with distance to the forest edge, but males defending territories closer to the forest edge were more successful in pairing than those in the forest interior. There was no significant relationship between territory size and arthropod biomass.

Keywords: *Basileuterus flaveolus*, birds, pairing success, territory size.

Introduction

Territoriality in birds has been widely studied by ecologists but territory size of Neotropical birds has been poorly studied, and there are disagreements about the adaptive value of territoriality (Hinde, 1956; Smith & Shugart, 1987; Møller, 1990; Rodrigues, 1996). Variations in habitat physical structure may indirectly affect territory size through other variables, and a correlation between territory size and habitat structure has been suggested (Smith & Shugart, 1987), as well as an inverse relation between territory size and population density, as demonstrated for two Parulinae species (Morse, 1976; Yamagishi & Ueda, 1986).

Studies on the ovenbird (*Seiurus aurocapillus*), a Neotropical migrant (Gibbs & Faaborg, 1990; Burkner & Nol, 1998) have shown the kind of demographic problems caused by fragmentation on forest-dependent birds. Abundance of *S. aurocapillus* was low in small fragments and close to the forest edge, and most males defending territories in these areas did not attract females (Gibbs & Faaborg, 1990). Furthermore, territory size varies among different forest types and during the breeding season (Stenger & Falls, 1959).

Basileuterus flaveolus is widely distributed from south and central Brazil, Paraguay and Bolivia, north to Pará and southeast Amazonas, northeast Colombia and adjacent areas of Venezuela (Hilty & Brown, 1986; Ridgely & Tudor, 1989; Mees & Mees-Balchin, 1990). It inhabits gallery forests, woody cerrado, caatinga, dry forests and forest edges, searching for food mostly on the ground or very low on the vegetation (Hilty & Brown, 1986; Mees & Mees-Balchin, 1990; Marini & Cavalcanti, 1993; Sick 1997). It is an insectivorous species, with 70% of its diet composed by Coleoptera (Durães & Marini, in press).

Our goals were to determine territory size for this species, its permanence time in a given territory, and the effect of forest edge on territory size and on male pairing success. We also evaluated seasonal and spatial variations in soil arthropod biomass, and its relation with *B. flaveolus* territory size.

Material and methods

Study area

We conducted this study in a 50 ha forest fragment located at the "Área de Proteção para fins de Preservação do Manancial do Barreiro" (from here on, Barreiro) (20°00' S, 43°59' W), in Belo Horizonte, Minas Gerais state, southeastern Brazil. This forest fragment is at the transition between the Cerrado and the Atlantic Forest domains (Veloso, 1966; Rizzini, 1979). However, its flora (CETEC, 1993) and its avifauna (pers. obs.) are more

Received: 05.IV.04

Accepted: 18.II.05

Distributed: 25.VIII.05

characteristic of the Atlantic Forest. Barreiro is a 2.000 ha reserve, dominated by open cerrado, but also containing 1 ha, 1.7 ha, 50 ha, and 200 ha forest fragments. The vegetation of the studied fragment is a seasonal mesophilous forest preserved for about 150 years. There is evidence that, in some of its areas, the forest was much more developed in the past (CETEC, 1993). The region has a strongly seasonal weather with a well-defined rainy season from October to March and a dry season from April to September.

Basileuterus flaveolus data collection

We captured birds monthly with 12-m long mist nets, from 1995 through 2000, at 12 net lines in the four forest fragments of the Barreiro region. Within the 50-ha fragment, birds were captured at four net lines, three of which inside an observation grid (see below). Some individuals of *B. flaveolus* were attracted to nets with their song playback. Birds were marked with metallic bands provided by CEMAVE (IBAMA) and unique combinations of three plastic color bands.

To evaluate residence time of individual birds in given areas, we used capture and recapture records of birds from 1995 to 2000 in the 12 net lines. Birds recaptured in the net line in which they had been previously captured were considered as residents in that area during the time interval between captures.

A 19.3 ha grid was established in the 50-ha forest fragment by opening long, narrow trails at 50 m intervals, creating several 50 m x 50 m squares. This grid included edge and interior forest areas. Observations were conducted inside the grid in 5-min stops at the trail intersection points. Singing individuals detected then had their bands identified, and were followed until disappearing. The area of the grid where each individual was observed was plotted on a map. When necessary, birds were attracted closer to the observer with a playback of its song to enable for their identification. Territories were recorded until their size ceased to increase. Observations were conducted with binoculars, mostly between 05:00 and 11:00 and between 15:00 and 17:00, from August to December 1998, February to July 1999, and September 1999 to January 2000, with a total sample effort of 916 hours of observation.

Territory sizes were calculated through the 'minimum polygon convex' method (Odum & Kuenzler, 1955), which consists in joining the outermost observation points for each bird with a straight line. The largest polygon obtained was taken as the bird territory size. Although this method has been subjected to criticism (Worton, 1987), it was chosen due to use simplicity and wide use in ornithology (e.g. Møller, 1990; Jullien &

Thiollay, 1998; VanderWerf, 1998; Brown et al., 2000; Wiktander et al., 2001; Remes, 2003).

Arthropod biomass data collection

During the non-breeding (dry) season and the breeding (rainy) season of 1999, the grid was sampled for arthropods. For this, we evenly distributed 10 pitfalls inside each territory, and collected all arthropods captured after five days. We also distributed 21 pitfalls between the territories in areas not defended by any bird. A pitfall consisted of a 500-ml plastic jar filled with 50 ml of a mixture of 2% formalin and detergent. Arthropods collected in the pitfalls were initially preserved in alcohol 70%, then dried in an oven for 24 h, and weighed on a METTER H10 scale ($d = 0,1$ mg). Thus, we used dry arthropod biomass estimation. Coleoptera larger than 1.5 cm were excluded from the analyses, since they were not considered potential prey for *B. flaveolus*. The foraging behavior of *B. flaveolus* suggests that its preys live on or close to the ground (Marini & Cavalcanti, 1993; Sick, 1997), which justifies the use of "pitfalls" to sample prey biomass.

Statistical analyses

Differences in mean arthropod biomass between seasons were tested with paired t-tests, considering all pitfalls as independent samples. Spearman rank correlation was used to evaluate the influence of forest-edge distance on territory size and arthropod biomass. The relationship between territory size and arthropod biomass in each territory was evaluated through the Pearson linear correlation coefficient. Differences in territory sizes among the three seasons were tested with the Kruskal-Wallis test. The difference in male pairing success between territories in the forest interior (> 100 m from the edge) and near the forest edge was tested with the Wilcoxon test. All statistical analyses followed Ott (1988), and were conducted using Systat for Windows (Wilkinson et al., 1992).

Results

Five years of banded-bird recapture indicate that *B. flaveolus* stay in the same territory for 1-3 years ($n = 16$). During the three seasons sampled, the *B. flaveolus* population density was 0.73 individuals/ha, and the mean territory size was of 2.0 ha (Tab. 1). There were no significant changes in territory size ($H = 0.832$; $df = 2$; $p = 0.660$) and most individuals defended basically the same areas during the whole study period. Territories close to the

Table 1 - Characteristics of *Basileuterus flaveolus* territory during three seasons in a 50-ha forest fragment in southeastern Brazil.

Season	Density (ind/ha)	Territory size (ha)	Distance to forest edge (m)	Paired males (%)	Arthropod biomass (gr.10 ² /pitfall)
Breeding 1998	0.73	2.0 ± 0.6	107.4 ± 90.8	75.0	–
Non-breeding 1999	0.73	2.2 ± 0.9	108.6 ± 68.5	75.0	6.34 ± 1.69
Breeding 1999	0.73	1.9 ± 0.8	136.0 ± 120.0	75.0	26.42 ± 6.68
Mean ± sd	0.73	2.0 ± 0.7	117.7 ± 98.6	75.0	16.38 ± 11.36

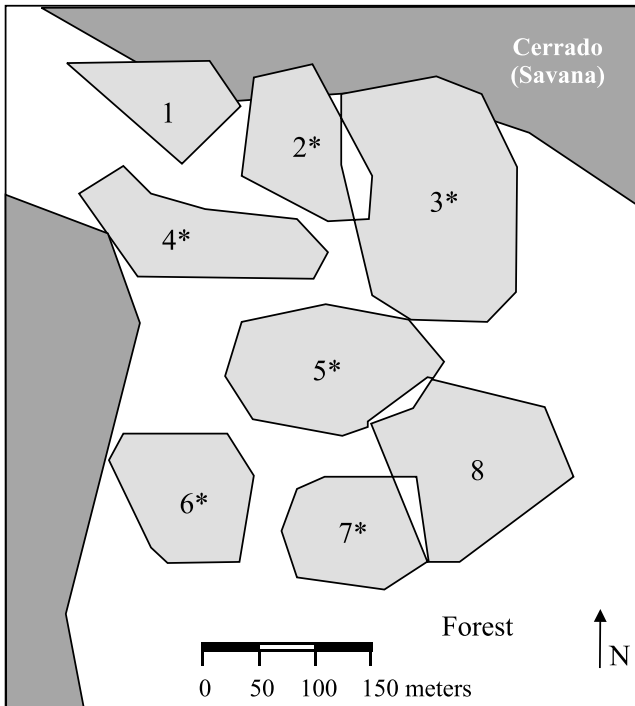


Figure 1 - Distribution of *Basileuterus flaveolus* territories in the 1998 breeding (rainy) season at a forest fragment in southeastern Brazil. Numbers indicate territory owner and numbers followed by an asterisk indicate mated individuals.

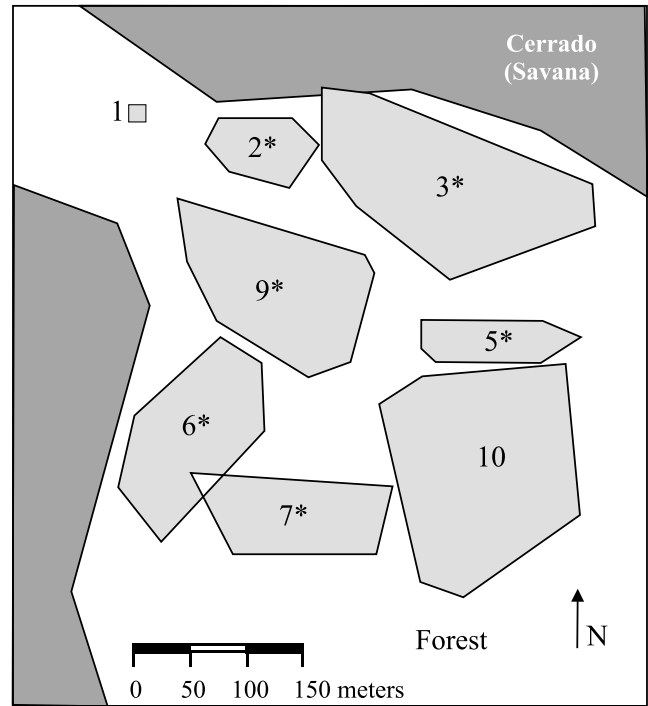


Figure 2 - Distribution of *Basileuterus flaveolus* territories in the 1999 non-breeding (dry) season, at a forest fragment in southeastern Brazil. Numbers indicate territory owner and numbers followed by an asterisk indicate mated individuals.

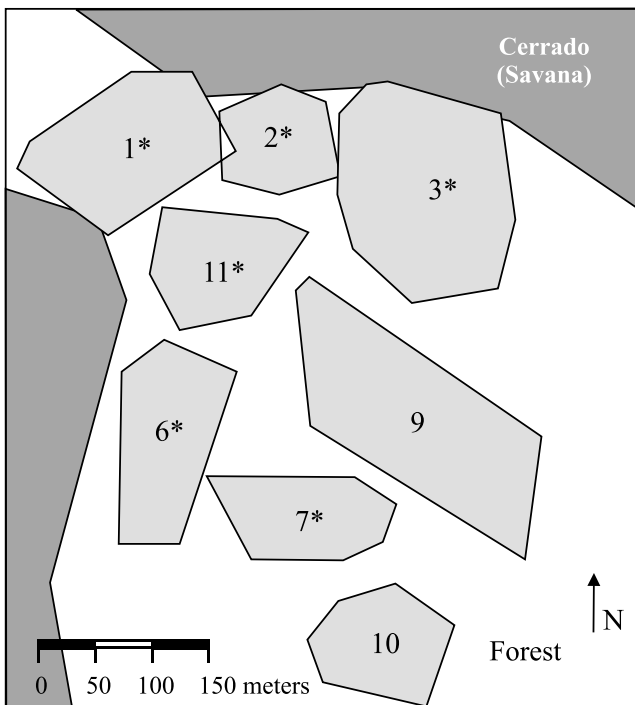


Figure 3 - Distribution of *Basileuterus flaveolus* territories in the 1999 breeding (rainy) season at a forest fragment in southeastern Brazil. Numbers indicate territory owner and numbers followed by an asterisk indicate mated individuals.

Legend:

- Cerrado (Savanna)
- Forest
- ▨ Territory

forest edge had significantly more paired individuals, than territories deep in the forest, when the three seasons were considered together ($z = 4.197$; $p < 0.001$).

Breeding season - 1998

The best-sampled territories ($n = 7$) varied in size from 1.3 ha to 3.1 ha (2.0 ± 0.6 ha in average – Fig. 1). In six of the eight territories, males were paired. There was no significant relationship between territory size and distance to the forest edge ($r_s = 0.643$; $df = 6$; $p = 0.119$).

Non-breeding season - 1999

Of the six pairs monitored during the previous breeding season, four (pairs 2, 3, 6 and 7) still defended the same areas (Figs. 1 and 2). A new pair (9 in Fig. 2) appeared in the sampling grid and occupied the area previously defended by Pair-4 (Fig. 1), which was no longer observed. Furthermore, the territory occupied by individual 8 (Fig. 1) was then defended by another individual (Individual-10 in Fig. 2). However, the most

interesting change involved territory size and location of Pair-5, which defended area decreased from 2.0 ha in the previous season to 0.8 ha. As a whole, eight territories were detected (Fig. 2), with the six best-sampled ones varying in size from 0.8 ha to 3.3 ha (2.2 ± 0.9 ha, in average). In six of the eight territories males were paired. There was no significant relationship between territory size and distance to the forest edge ($r_s = 0.029$; $df = 5$; $p = 0.957$). Again, territory size was not significantly correlated with arthropod biomass ($r = 0.395$; $df = 5$; $p = 0.333$).

Breeding season - 1999

Pairs 2, 3, 6 and 7 remained in the same territories (Figs. 1, 2 and 3) they occupied since the 1998 breeding season. Individual 10 changed its territory location and its vacant space was occupied by one of the individuals of Pair-9, which lost its mate (Figs. 2 and 3). Other pair defended the area occupied by Pair-9 in the previous season (Pair-11 in Fig. 3). Individual-1 attracted one mate in this season.

Eight territories were delimited (Fig. 3) with their sizes varying from 1.1 ha to 3.4 ha (1.9 ± 0.8 ha, in average). In six of these eight territories, males were paired. There was no significant relationship between territory size and distance to the forest edge ($r_s = 0.503$; $df = 7$; $p = 0.204$). Again, territory size was not significantly correlated with arthropod biomass ($r = 0.510$; $df = 7$; $p = 0.242$).

Arthropod Biomass

Arthropod biomass did not vary with the distance to forest edge, varying randomly across the grid. There was no significant relationship between arthropod biomass and distance to the forest edge, neither in the dry season ($r_s = -0.026$; $n = 101$; $p > 0.50$), nor in the rainy season of 1999 ($r_s = -0.016$, $n = 101$; $p > 0.50$). Arthropod biomass varied significantly ($t = -9.171$; $df = 7$, $p = 0.000$ – Tab. 1) between the dry and the rainy seasons of 1999, with a biomass 4.2 times higher during the rainy season, as compared to the dry season.

Discussion

Both mean territory size and density of individuals varied little during the seasons studied. The relationship between territory size and density of individuals has already been described for other Parulinae (Morse, 1976; Yamagishi & Ueda, 1986). Furthermore, in the tropics, yearlong territory defense is common and adult survival high, so breeding vacancies may be scarce (Stutchbury & Morton 2001). Since there was no variation in the population density during the study, a correlation with territory size could not be conducted. However, it seems that the population is at its carrying capacity, and territory sizes are at their minimum.

Greenberg & Gradwohl (1986) observed that three species of antbirds from Barro Colorado Island, Panama, had a moderate change of territory owners, but territories remained mostly the same year after year. Oppositely, the home range of two pairs of the Hawaii Creeper (*Oreomyza mana*), increased 346% and 180% in size from the reproductive season to the non-reproductive season (VanderWerf, 1998). Despite the substi-

tutions of some territory owners and strong changes in arthropod biomass between seasons, territory sizes of *B. flaveolus* changed little between seasons. Birds recorded in all three seasons in the grid defended basically the same territory, suggesting a year-round territorial system.

The 'ecological trap hypothesis' (Gates & Gysel, 1978) predicts that birds would be attracted to forest edges because arthropods would be more abundant there, but would suffer higher nest predation rates because of higher predator abundance and richness. Our data did not support this hypothesis since there was no difference in arthropod biomass between forest edge and forest interior. Thus, at least in the fragment we studied, arthropod biomass did not seem to drive territory selection by *B. flaveolus*. Since in another study developed in the same forest fragment, nest predation did not vary significantly between forest edge and forest interior (Duca & Marini, 2001), nest predation also does not seem to drive territory selection in the study area.

Basileuterus flaveolus territories were distributed randomly in the grid, with apparently no influence of the forest border on the size of the defended area. Females of forest-interior species, such as *S. aurocapillus*, avoid forest edges, apparently responding to their high predation risk and low food availability (Burker & Nol, 1998). Abundance of this species is low in these areas and males have low pairing success when defending territories close to forest edges, apparently because females avoid these areas (Gibbs & Faaborg, 1990). Oppositely, *B. flaveolus* seems to be an edge species, as proposed before (Hilty & Brown, 1986; Sick, 1997), since males defending territories close to edges had higher pairing success than males defending territories in the forest interior.

Sizes of *B. flaveolus* territories were relatively small (~2 ha) even for a small tropical passerine (body mass ~13.4 g). No bird at Cocha Cashu has a territory as small as 2 ha (Greenberg & Gradwohl, 1986) and in the Peruvian Amazon no species occupied a territory smaller than 3 ha (median = 9 ha) (Terborgh et al., 1990). Among the species studied by Terborgh et al., the ground flycatcher ringed antpiper (*Corythopis torquata*) (17 g) and the Ihering's antwren (*Myrmotherula iheringi*) (8 g) defended territories of 6 ha and 4 ha, respectively. In gallery forests of central Brazil, however, the frugivorous helmeted manakin (*Antilophia galeata*) (20 g) defended small (0.60 ha - 0.96 ha) areas (Marini & Cavalcanti, 1992). The same was true for the black-hooded antwren (*Formicivora erythronotos*), with size similar to that of *B. flaveolus*, which also defended small territories (0.3 ha - 1.67 ha) in the Atlantic Forest of Rio de Janeiro state (Mendonça & Gonzaga, 1999). This suggests that territories of *B. flaveolus* and *F. erythronotos*, in Atlantic Forest areas, may be smaller than the ones of similar-sized passerine species living at the Amazonian forest.

Our study showed that *B. flaveolus* defends small territories (~2.0 ha), for several years. Distance from forest edge did not influence territory sizes, but apparently affects male pairing success, supporting the assertion that *B. flaveolus* is an edge species. Food abundance (arthropod biomass) had no relationship with territory size and location, and in spite of the strong seasonal arthropod variation, territory sizes did not vary between dry and the rainy seasons. Probably, territory size is related to population density, but that does not implicate that its selection might not be related to other factors besides density,

such as vegetation characteristics, a hypothesis that remains to be tested.

Acknowledgments

CNPq provided financial support and fellowships to both authors. COPASA (Companhia de Saneamento de Minas Gerais) allowed the study to be conducted in their properties. Dr. A. L. Melo helped with arthropod biomass estimations. C. E. Carvalho, H. Belfort, F. Siqueira, G. J. Viana and T. Guerra helped with data collection. Dr. M. Rodrigues and an anonymous reviewer kindly made suggestions to the manuscript.

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