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TERRITORIAL BEHAVIOR OF THE GREATER WAGTAIL-TYRANT (*Stigmatura budytoides*) IN THE CENTRAL PORTION OF THE MONTE DESERT

M. Cecilia Sagario[1,2*], Carolina Guerra Navarro[1,3], Javier Lopez de Casenave[1] & Victor R. Cueto[1,4]

[1]Grupo de Investigación en Ecología de Comunidades de Desierto (ECODES). Departamento de Ecología, Genética y Evolución, Facultad de Ciencias Exactas y Naturales, Universidad de Buenos Aires e IEGEBA (UBA-CONICET). Piso 4, Pabellón 2, Ciudad Universitaria, C1428EHA. Buenos Aires, Argentina

[2]Grupo de Ecología Terrestre de Neuquén. Sede Junín de los Andes del Instituto de Investigaciones en Biodiversidad y Medioambiente (INIBIOMA, Universidad Nacional del Comahue - CONICET). Centro de Ecología Aplicada del Neuquén. Ruta Provincial 61 km 3, San Cabao, CP8371. Junín de los Andes, Neuquén, Argentina

[3]Facultad de Turismo y Urbanismo, Universidad Nacional de San Luis. Av. del Libertador S/N, Barranca Colorada, CP5881. Villa de Merlo, San Luis, Argentina

[4]Laboratorio de Ecología de Aves. Centro de Investigación Esquel de Montaña y Estepa Patagónica (CIEMEP, CONICET y Universidad Nacional de la Patagonia San Juan Bosco). Gral. Roca 780, U9200. Esquel, Chubut, Argentina

*mctatysagario@gmail.com

ABSTRACT: Studying bird territories provides insight into their requirements and the limitation of their populations. We monitored Greater Wagtail-Tyrants (*Stigmatura budytoides*) in the central Monte over five years, where a small proportion of the population established territories that saturated the study plot. Individuals maintained their territories throughout the year, often in consecutive years, and selected high perches in Algarrobo trees (*Neltuma flexuosa*) for their defense. The average territory size was 1.4 ha, and territories were larger with greater overlap during the non-breeding season. Pairs remained together throughout the year and both members defended the territory. In several seasons both members developed brood patches, indicating that males might be incubating. We observed juveniles singing within their parents' territory. Although we obtained information from few individuals, the territorial patterns (stable territories, strong pair bonds, retention of juveniles in the territory), together with previous evidence (small clutch size, low reproductive success, high longevity, prolonged parental care), suggest that the Greater Wagtail-Tyrant has life-history traits shared with tropical birds and contrast with those of temperate-climate birds of the Northern Hemisphere.

KEYWORDS: *life-history traits, South America, territorial stability, territories, Tyrannidae*

Territoriality is the defense of an area (territory) for the purpose of monopolizing resources, which may include food, shelter, mates, or nest sites, among others (Newton 1998, Adams 2001). In birds, the most common form of territory defense is acoustic communication (songs and calls) and the chasing of intruders, which may be carried out by a single member of the pair, usually the male, or by both (Catchpole & Slater 1995, Lovette & Fitzpatrick 2016). The spatiotemporal distribution of the defended resources can determine territory size and whether or not it is defended year-round (Brown 1969, Adams 2001, Golabek et al. 2012). Acquiring a territory can be decisive not only for an individual's fitness (e.g., Maguire 2006, Flockhart et al. 2016), but can also regulate population density through the exclusion of individuals when the area is saturated (Newton 1998, Lovette & Fitzpatrick 2016). Thus, the study of bird territories is crucial to understanding both their requirements and the limitation of their populations.

Stutchbury & Morton (2023) suggested that

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territorial behavior should be similar in birds of tropical and temperate zones of South America (e.g., stable territories and pairs due to lower seasonality and higher survival), but different from birds of temperate zones of North America (e.g., breeding territories in spring-summer and shorter pair bonds due to greater seasonality and lower winter survival). However, this hypothesis has not been evaluated in much detail, perhaps due to the scarce information available on numerous aspects of the natural history of Neotropical species (Lees et al. 2020, Stutchbury & Morton 2023). For example, to our knowledge, detailed information on territory sizes and territorial behavior in natural populations (i.e., without the use of nest boxes) of passerines in temperate environments of South America is limited to a few published articles and doctoral theses. Studies conducted in southern Brazil (Chiarani & Fontana 2015, Beier et al. 2017, Rosoni et al. 2024), in eastern (Fraga 1980, Di Giacomo et al. 2011, Colombo 2022) and west-central Argentina (Lacoretz et al. 2012, Sagario & Cueto 2014a, 2014b, Zarco 2016), and in Patagonia (Diaz et al. 2006, Presti 2019) do not show uniform patterns regarding mating systems, territory size, the defensive role of one or both sexes, territory fidelity, or fidelity within pairs.

The Greater Wagtail-Tyrant (*Stigmatura budytoides*) is a small insectivorous tyrannid (8-13 g) whose pairs sing in duet and which is distributed mainly through the west-central portion of southern South America, from Bolivia to the northern limit of Argentine Patagonia, with a small disjunct population in northeastern Brazil (Fitzpatrick 2020). Despite being a locally abundant, conspicuous species with a wide distribution, little information is available on its natural history (Fitzpatrick 2020). Data on its clutch size (two eggs; Mezquida 2002), reproductive success (26%; Mezquida & Marone 2001), longevity (95 months; Cueto et al. 2025), apparent annual survival (ϕ = 0.495, França et al. 2023), and autumn-winter formation of family groups (Zarco & Cueto 2017) come entirely from the Monte desert in Argentina.

In an effort to learn about aspects of the natural history of Monte desert birds, we carried out demographic monitoring with constant-effort mist-net captures (see Ralph et al. 1995) between 2004 and 2009 in an Algarrobo woodland in the central portion of the Monte desert (Mendoza, Argentina). The aim of this study is to describe aspects of the territorial behavior of Greater Wagtail-Tyrants in the central Monte that arose from this monitoring, and to discuss its consistency with the patterns expected for birds of temperate zones of South America. We report general aspects concerning residency, the occurrence of external indicators of reproductive activity (cloacal protuberances and brood patches), and territoriality in all individuals captured during the monitoring. We report perch selection by adults for singing and raise questions about the potential involvement of males in egg incubation and of juveniles in territory defense. For the captured territorial adults, we detail intra- and interannual fidelity to territory location and to pairs, as well as the seasonal variation in territory size.

METHODS

We conducted the study in Ñacuñán (34°03'S, 67°54'W), a 12,880-ha reserve of the UNESCO Man and the Biosphere Program located in the central portion of the Monte desert, in Mendoza Province, Argentina (Fig. 1). The predominant environment in the reserve is an open woodland (Algarrobo woodland) dominated by Algarrobo (*Neltuma flexuosa*) and Chañar (*Geoffroea decorticans*) trees scattered within a matrix of Jarilla (*Larrea divaricata*) and other tall shrubs. The area has hot summers and cold winters. On average, >75% of annual rainfall occurs during spring and summer (October to March) and is highly variable between years (mean annual rainfall ± SD: 348 ± 123 mm, range 91-715 mm, 1972-2020 period; see Lopez de Casenave 2001 for a more detailed description).

We captured and observed the territorial behavior of Greater Wagtail-Tyrant individuals during spring (November), summer (February), autumn (May), and winter (August), between spring 2004 and winter 2009, except in autumn of the last year (a total of 19 sampling events). Birds were captured with mist nets (12 m long, 38 mm mesh) set at fixed locations along three parallel lines of 10 nets each (i.e., a total of 30 nets) spaced 50 m apart within a 10-ha permanent plot located in the Algarrobo woodland. During each sampling event, nets were opened during the first four-five hours after dawn for six consecutive days whenever weather conditions were favorable (i.e., on days without rain, strong winds, or extreme cold or heat). Mean sampling effort (± SD) with nets per event was 738.8 ± 18.8 net-hours (n = 19).

Captured birds were classified as juveniles (individuals that had probably hatched at the site) or adults. In the Greater Wagtail-Tyrant, adult and juvenile plumages are similar, so juveniles were distinguished by the presence of soft, swollen, yellow gapes. Birds that could not be unambiguously assigned an age were classified as adults. Both adults and juveniles were marked with numbered aluminum bands and unique

combinations of color bands. To determine the reproductive status of adults, we recorded the presence and condition of their brood patches and cloacal protuberances. A bird was considered reproductive when it had a smooth, vascularized, wrinkled, or molting brood patch, or when it had a small, medium, or large swollen cloacal protuberance (see Ralph et al. 1995). We expected that these external indicators would allow us to determine the sex of individuals, because in most reproductively active passerines, males show conspicuous cloacal protuberances and females have brood patches (Ralph et al. 1995, Pyle et al. 2015). However, given the characteristics recorded in this species (see Results), we were unable to discriminate the sex of captured individuals.

After the mist-netting period, we conducted intensive daily searches for banded birds within the permanent plot and up to 50-100 m beyond its boundaries (a minimum total search area of 18 ha) during the first four hours after dawn and the last two hours before sunset, for a maximum of 10 days or until no new banded individuals were seen after 10 hours of searching. Mean search effort (± SD) per sampling event was 51.4 ± 5.8 person-hours (n = 19), during which the entire search area was systematically covered at least once a day. Each time a marked bird was found, its identity and location were recorded and the survey continued (i.e., individuals were not followed once their identity had been confirmed). Whenever an individual (marked or not) was found singing, we recorded the plant species and the height at which it was perched.

We assessed perch availability in the environment by estimating horizontal and vertical vegetation cover in the central 10 ha of the search area, recording all plant species that touched a vertical pole (graduated every 0.25 m) placed at 189 sampling points. The location of these points was determined by randomly selecting (using random-number tables) an orientation (between 0° and 359°) and a distance (between 0 and 12 m) from each vertex resulting from dividing the plot into 25 × 25 m squares. We assessed selection of plant species and singing heights using Manly's Selectivity Index (Manly et al. 2002), where index values close to 1 for the evaluated resource indicate no selection, values below 1 indicate avoidance, and values above 1 indicate selection. For the calculation we used the '*widesII*' function (in which use is estimated for individuals and availability is measured for the population) in the '*adehabitatHS*' package (Calenge

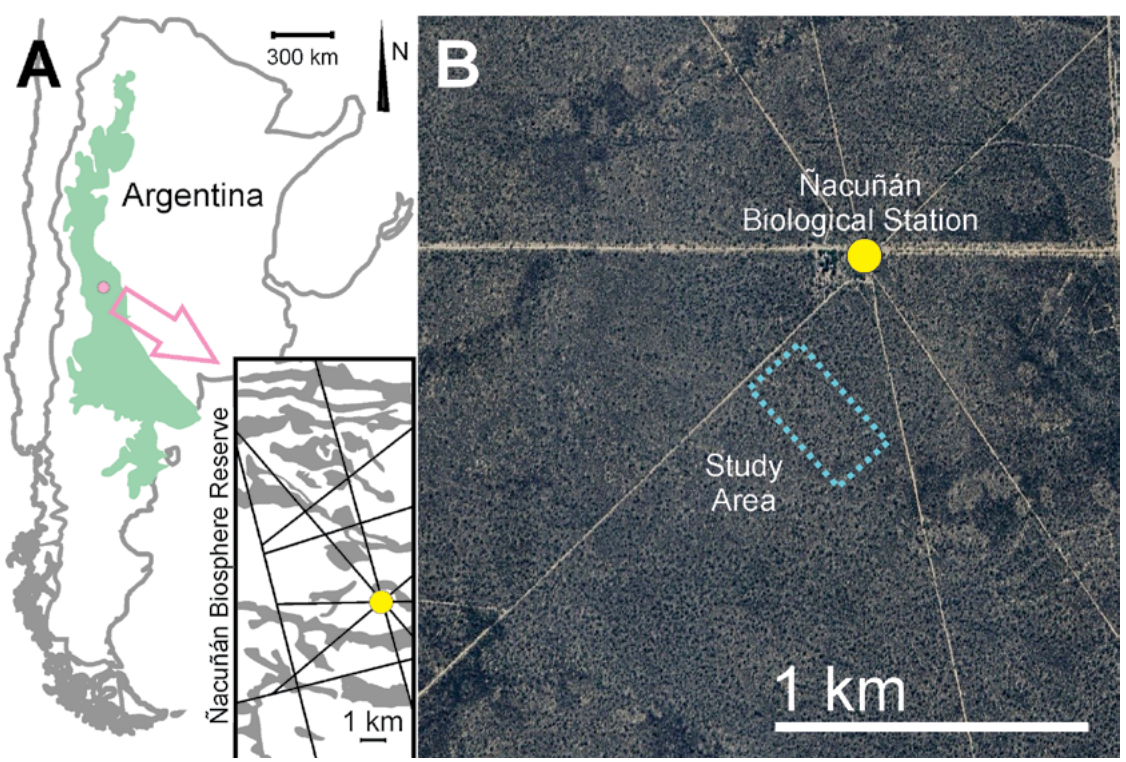

Figure 1. (A) Location of the Ñacuñán Biosphere Reserve (pink circle) in the Monte desert (green area) and map of the reserve showing its two main environments: *Larrea cuneifolia* shrublands (jarillales, gray areas) and *Neltuma flexuosa* open woodlands (algarrobales, white areas). (B) Location of the study area in a satellite image of a sector of the reserve near its biological station (yellow circles in A and B).

2006) in the R program (R Core Team 2025).

We considered as territorial individuals those adults that were recorded performing defense displays (songs or chases) within the search area and that were consistently relocated (i.e., recaptured or resighted; at least five relocations, not all on the same day) during the same breeding or non-breeding season. We defined breeding pairs based on records of joint relocations (i.e., two individuals without signs of aggression located less than 5 m apart), duet singing, or occurrence within the same territory, and, in some cases, also because they built a nest or fed fledglings. To assess pair fidelity within and between years, we recorded the percentage of events in which, based on pairs identified during a breeding season, we relocated both members, only one, or neither. This analysis was carried out by comparing it with the following non-breeding season (within-year fidelity) and the breeding season of the following year (interannual fidelity).

To characterize territory size, all relocations of both territorial adults of each pair were imported into a geographic information system (QGIS 3.28.9; QGIS Development Team 2023), separately for the breeding and non-breeding seasons. For each year and season we calculated the territory size of each individual (i.e., the used area) using the minimum convex polygon approach, connecting its outermost locations and forming a polygon whose internal angles do not exceed 180° (Mohr 1947). To estimate fidelity to territory location, we calculated the areas of each individual's polygons and assessed the distance between territory centroids for the same individual in consecutive years. For territory size calculations, we prioritized having at least 10 relocations per territory (10 to 26 relocations, n = 20 territories) and used territories with fewer than 10 relocations (5 to 9 relocations, n = 17 territories) in cases where the estimated areas were similar to those of individuals with more relocations. To compare territory size between the breeding and non-breeding seasons while accounting for potential correlation of data from the same individual, we used generalized estimating equations assuming a compound ('exchangeable') correlation structure with the '*geepack*' package (Højsgaard et al. 2006) in the R program (R Core Team 2025).

The minimum convex polygon is a widely used and comparable method for estimating territory size or home range, although it does not allow for assessing the intensity of individual use within those areas. To assess that intensity we used kernel density functions (Worton 1989). These functions produce concentric areas or bands having similar probabilities of finding the individual; probability of use calculations is based on the intensity of use (i.e., the number of locations) and decreases toward the exterior. The width of the bands is defined by the smoothing parameter h, and the optimal bandwidth ('hopt') was calculated using the formula proposed by Bolstad (2016): hopt = SD (2 / 3n) ^ 0.25, where n is the number of locations and SD is the standard deviation of the distance between all locations and the center of their distribution. From the density functions we estimated space-use exclusivity throughout the study, measuring the percentage of overlap between contiguous territories of different individuals in the breeding and non-breeding seasons.

RESULTS

In total we made 256 captures of 109 adults and 17 juveniles of Greater Wagtail-Tyrant. All juveniles were relocated (i.e., recaptured or resighted) at least once, and the great majority (82%) only during their first year. Most adults were captured during the non-breeding season (capture rate 72.7 ± 21.4 captures/100 net-hours in spring-summer and 185.7 ± 33.5 captures/100 net-hours in autumn-winter; generalized estimating equations: $W = 66.2$, $p < 0.001$, 5 years with 2 seasons) and were relocated on no occasions (53%) or on very few occasions throughout the study (<5 relocations, 24%). We recorded 12% territorial adults among captured individuals, while for the remainder (11%) we did not record defense activities (60% of these last individuals were relocated only during the non-breeding season). Of the adults captured during the breeding season (spring and summer, n = 52), 53% did not have a swollen cloacal protuberance; in the rest we observed small (39%) or medium (8%) protuberances. We recorded active brood patches (smooth, vascularized, wrinkled, or molting) in 71% of adults. In 40% of adults we simultaneously recorded the presence of a swollen cloacal protuberance (small or medium) and a developed brood patch (smooth or vascularized) or evidence of having been developed (wrinkled or molting). In two of the four focal individuals that we recorded as territorial (see below), we recorded a brood patch in both them and their partners in some of the captures (for the other two we lack information because we were unable to capture the focal individual or its partner during the breeding season). Only one of the focal individuals was identified as a male because its partner laid an egg during one of its captures and had shown a smooth patch in one breeding season and a wrinkled patch in another.

We found evidence of territory defense (i.e., songs

and chases) both in the breeding and the non-breeding seasons, and the rates at which we observed these events (number of observations of defense activities per 100 hours of searching) were similar between seasons, with a mean (± SE) of 19.4 ± 3.8 during the breeding season and 19.2 ± 4.5 during the non-breeding season (n = 5). When singing, adults preferred to perch on Algarrobo trees (Manly's Selectivity Index ± CI: 4.8 ± 0.9, n = 26) and on the highest perches (>3 m) of the vegetation (11.4 ± 3.1, n = 20). The confidence intervals of the selectivity index values for other plant species (Chañar, Jarilla, other tall shrubs) and height categories (0-1 m, 1-2 m) included values less than or equal to 1, indicating no selection.

Throughout the study we identified only 10 adults that established their territories within the search area (and another three whose territories extended beyond the search area and were therefore not mapped), four of which had the highest number of relocations and consecutive years in which they were observed (hereafter called focal individuals), and six that we were able to identify at different times as their partners. Focal individuals established their territories in the study area during at least four of the five years sampled (three focal individuals during four breeding seasons and one during five). Two of them were recorded every year with the same partner, another with two different partners, and the fourth with three partners. We repeatedly recorded both members of the pairs, both between the breeding and non-breeding seasons of the same year (82%) and between breeding seasons of consecutive years (55%). When a focal individual was relocated with a new partner, we did not relocate its previous partner again in the study area. Both members of the pairs were relocated singing within the focal individuals' territories during the breeding and the non-breeding seasons, and on five occasions we observed juveniles (n = 4) singing within their parents' territory.

We mapped a total of 37 territories of the four focal individuals and four of their partners across all seasons and years, with mean sizes (± SE) of 1.4 ± 0.1 ha overall, 1.2 ± 0.1 ha during the breeding season (n = 19 territories of 8 individuals), and 1.7 ± 0.1 ha during the non-breeding season (n = 18 territories of 7 individuals). Territory sizes of focal individuals were larger during non-breeding seasons than during breeding seasons (generalized estimating equations: W = 9.4, p = 0.002, 29 observations from 4 individuals; Table 1), and the distances between territory centroids in consecutive years did not vary between seasons (W = 1.4, p = 0.240, 20 observations from 4 individuals; Table 1). Considering the full set of relocations of each focal individual throughout the study, the area used during the non-breeding season was larger than during the breeding season (W = 16.8, p < 0.001, 8 observations from 4 individuals; Table 1). The overlap of areas used among focal individuals throughout the entire study was greater during the non-breeding season than during the breeding season, both for total territory area (W = 5.9, p = 0.016, 12 observations from 6 pairs of individuals) and for the core area, although in the latter case only a very small overlap was recorded during the non-breeding season (Fig. 2; Table 1).

We also mapped the relocations for focal individuals' partners, but the small number of relocations in each season did not allow us to map the territories for every partner during every season or to perform statistical comparisons. The mean territory sizes (± SE) for focal individuals' partners were 0.7 ± 0.1 ha (Min-Max: 0.4-1.0 ha, n = 5) during the breeding season and 1.6 ± 0.2 ha (Min-Max: 1.1-1.8 ha, n = 3) during the non-breeding season. Considering relocations throughout the entire study, overlap of the territories mapped for focal individuals and their partners was high in the breeding (85 ± 12%, Min-Max: 50-97%, n = 4) and non-breeding seasons (90 ± 6%, Min-Max: 77-100%, n = 4).

DISCUSSION

Our results indicate that there is a core of sedentary Greater Wagtail-Tyrant individuals that maintain fixed territories across years and seasons in the central Monte. Changes in abundance and the few relocations detected through mist-net monitoring suggest that many individuals are also at least locally mobile, especially during the non-breeding season. This pattern has already been reported for granivorous birds in the central Monte (Sagario et al. 2014). We do not know the origins of these individuals (e.g., local movements of flocks or groups of juveniles, arrival of individuals from other areas), their fate (e.g., differential mortality during the non-breeding season, permanent emigration of juveniles, long-distance movements to breed elsewhere), the causes of their movements (e.g., changes in resource availability, saturation of the area by territorial individuals), or their consequences (e.g., competition for space, food, or mates with territorial individuals). Movement patterns of individuals cannot be determined through banding within a small area relative to a species' potential movement range (see Chan 2001), and characterizing these patterns is beyond the scope of this study.

Table 1. Mean values (± SE) of territory size, distances between territory centroids in consecutive years, and overlap between contiguous territories of four focal Greater Wagtail-Tyrant (*Stigmatura budytoides*) individuals during the breeding and non-breeding seasons of 2004-2009 in the Algarrobo woodland of the Ñacuñán Biosphere Reserve, Mendoza, Argentina. Values obtained from the observations of each season and from the total observations throughout the entire study are shown.

	Mean 2004-2009		**Total**	
	Breeding	**Non-breeding**	**Breeding**	**Non-breeding**
Size (ha) [min-max]	1.4 ± 0.2 [0.8 – 2.5]	1.7 ± 0.2 [1.0 – 2.6]	2.9 ± 0.3 [2.2 – 3.7]	4.0 ± 0.2 [3.6 – 4.5]
n	14	15	4	4
Distance (m) [min-max]	41 ± 5 [18 – 71]	61 ± 9 [21 – 101]		
n	10	10		
Overlap (%)				
Core [min-max]			0	0.2 ± 0.2 [0 – 1]
Total territory [min-max]			4 ± 3 [0 – 17]	11 ± 4 [2 – 23]
n			6	6

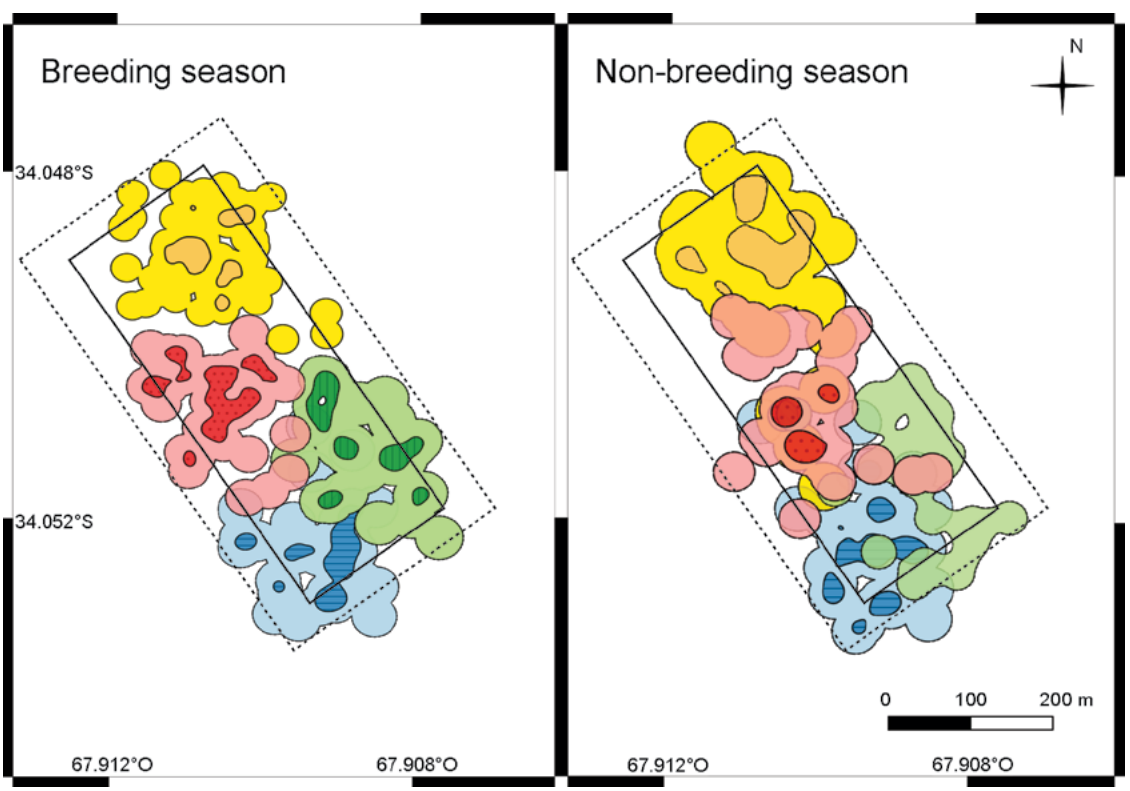

Figure 2. Territories of four focal Greater Wagtail-Tyrant (*Stigmatura budytoides*) individuals during the breeding and non-breeding seasons of 2004-2009 in the Algarrobo woodland of the Ñacuñán Biosphere Reserve, Mendoza, Argentina. The boundaries of the mist-netting sampling area (solid line) and of the search area (dotted line) are shown, along with the areas with 95% kernel density values (total territory: light-toned areas) and 50% (core: dark-toned areas). Each color corresponds to a different focal individual.

During the breeding season, mist-net monitoring indicated 71% of the individuals possessed active brood patches. This value is high compared to other abundant resident species (n > 30) captured in the central Monte during our monitoring (mean ± SE: 31% ± 2%; Min-Max: 26-37% for *Anairetes flavirostris*, *Asthenes baeri*, *Microspingus torquatus*, *Saltatricula multicolor*, *Tarphonomus certhioides*, and *Zonotrichia capensis*). We also documented the presence of active brood patches in both members of some Greater Wagtail-Tyrant pairs. These results indicate that both sexes may participate in egg incubation. The only detailed description of the reproductive biology of the species indicates both sexes participate in nest building, but provides no information on who is involved in incubation (Mezquida 2002). Although it is generally rare among tyrannids (Winkler et al. 2020), cases are known in which both sexes incubate (e.g., *Serpophaga griseicapilla*, Mezquida & Marone 2000; *Arundinicola leucocephala*, Farnsworth & Langham 2020), or in which males at least develop a brood patch (e.g., four species of the genus *Myiarchus*; Pyle 1997). Male incubation in the Greater Wagtail-Tyrant should be evaluated in more detail.

We detected defense activities by adults (songs and chases) during the breeding and the non-breeding seasons, and recorded that their songs are given from high perches located in Algarrobo trees, a species known to play an important role in territory selection and defense by birds in the central Monte (Lacoretz et al. 2012, Sagario & Cueto 2021). Duet singing and the high overlap of territories between pair members indicate both males and females actively participate in territory defense (e.g., Diniz et al. 2020), while observations that juveniles sing while sharing the territory with their parents suggests that they could also participate in territorial defense. The role played by the different members of the family group in territory defense is another interesting aspect that deserves further exploration.

Territorial adults remained socially faithful to their partner and territory throughout the year, and some pairs also remained together in consecutive years, as occurs in many other Neotropical species (Stutchbury & Morton 2023), including some of the central Monte (e.g., *Microspingus torquatus*, *Saltatricula multicolor*, and *Zonotrichia capensis*; Sagario & Cueto 2014b). However, we found that one of the pair members (the focal individual) was more faithful to the territory between years and showed more frequent and conspicuous defensive behaviors, as it was relocated more often. Because we were unable to sex the individuals, we could not determine whether this behavior was linked to a particular sex. Although this behavior is usually associated with males in many Neotropical species (e.g., Fraga 1980, Rosoni et al. 2024), more studies are needed to determine whether differences in fidelity (or mortality) exist between territorial Greater Wagtail-Tyrant males and females. Mean territory size during the breeding season (1.2 ± 0.1 ha) fell within the ranges reported for males of other resident small passerine species of the central Monte during the same season (1.2-1.6 ha for *Microspingus torquatus*, 0.7-1.7 ha for *Saltatricula multicolor*, and 0.5-1.2 ha for *Zonotrichia capensis*; Sagario & Cueto 2014a). However, these three species feed mainly on seeds during autumn and winter and do not establish territories during that time of year (Sagario & Cueto 2014a). These differences may be due to a different distribution of their resources or to changes in the costs and benefits of monopolizing an area at different times of year. For example, in the case of the Greater Wagtail-Tyrant, the territories of focal individuals were larger and overlapped more with those of other individuals during the non-breeding season. This territorial overlap may respond to the need for a larger area to meet food requirements, or to an unfavorable cost-benefit ratio for maintaining exclusive access to resources due, for example, to a lower abundance of arthropods (Guerra Navarro & Cueto 2024), to the localized and spatially scattered occurrence of Algarrobo trees providing sap exudates (which the Greater Wagtail-Tyrant often feeds on; Genise et al. 1993, Blendinger 1999), or to a greater abundance of competitors (as evidenced by a higher adult capture rate at that time of year).

The choice of the survey area, the fixed location of the mist nets, and the systematic search protocols were based on optimizing the study design for population monitoring, but resulted in tracking a small number of territorial adults because the area was saturated by a few sedentary individuals. Nevertheless, our findings allow inferences about the territorial behavior of this species, such as social monogamy, the stability of territories and pairs throughout the year, the probable defense of the territory by both pair members given the overlap of their territories and duet singing, the potential participation of the male in incubation, and the potential existence of differences between males and females in interannual territory fidelity. These patterns are expected in tropical species and suggested for species of temperate environments of South America (Stutchbury & Morton 2023). Within Argentina, a large number of these behaviors were

reported in other species, such as *Furnarius rufus* (see review in Mentesana et al. 2024) and *Polioptila dumicola* (Fraga & Salvador 2013). We also confirmed that juveniles remained in the adults' territories during their first year and showed defense activities. Martin (1996) hypothesized that the prolonged retention of juveniles in the natal territory after independence may increase their survival without increasing the parents' reproductive effort. This pattern would be expected mainly in birds of the Southern Hemisphere, whose reproductive investment is lower than that of species from temperate zones of North America (Martin 2004, Stutchbury & Morton 2023). These results, together with evidence previously reported in the literature such as small clutch size and low reproductive success (Mezquida & Marone 2001, Mezquida 2002), high longevity (Cueto et al. 2025), and prolonged parental care (Zarco & Cueto 2017), suggested that the Greater Wagtail-Tyrant has a 'slow pace of life' (Wiersma et al. 2007). This way of life is characterized by individuals that live a long time and invest less in reproduction, producing few offspring, traits shared with tropical birds that contrast with those observed in temperate-climate birds in the Northern Hemisphere (Martin 2004, Stutchbury & Morton 2023).

Basic data on the natural history of South American birds such as those presented in this study remain relatively scarce compared to Europe and North America (Lees et al. 2020, Stutchbury & Morton 2023). Nevertheless, these data are fundamental for contrasting avian life-history strategies (Martin 1996) and to generate new hypotheses regarding these strategies and facilitate their testing (Anderson 2017, Nanglu et al. 2023, Marone & Jaksic 2025).

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USE OF ARTIFICIAL INTELLIGENCE

We have not used artificial intelligence at any stage of this study.

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