MANAGING SMALL GRASSLAND RESERVES: BIRD RESPONSE TO REGENERATIVE GRAZING IN A PRIVATE RESERVE IN ARGENTINA

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ABSTRACT

In the grassland biomes of southern South America, high agricultural land value limits the expansion of protected areas, making conservation on private lands through voluntary schemes essential. These frequently limited in size reserves require livestock grazing management to maintain biodiversity, yet the effects of specific regimes like regenerative grazing on birds remain unstudied in the hill grasslands of the Pampean region. We evaluated the bird assemblage response to experimental regenerative grazing by comparing it to traditional grazing and no-grazing controls on a ranch with a Private Reserve in the Tandilia Hills in the Pampean region of Argentina. We recorded 36 bird species, including 24 habitat generalists and 12 grassland specialists. Bird abundance was affected by grazing conditions. Grassland specialists were positively associated with increased grassland structure, while generalists showed the opposite response. Vegetation structure was lower with traditional grazing, intermediate with regenerative grazing and maximum without grazing. The frequency and timing of grazing should allow for rest to ensure a complex vertical structure for grassland birds during the nesting period. Innovative grazing in small reserves supports sustainable use and habitat continuity in the Tandilia Hills, but its application requires cautious timing to avoid compromising grassland bird habitat during breeding season.

Keywords: Livestock, grassland birds, small area, private, reserve, Tandilia, South America

RESUMEN

En los pastizales del sur de Sudamérica, el alto valor económico de la tierra para la agricultura limita la expansión de las áreas protegidas, lo que hace que la conservación en tierras privadas mediante esquemas voluntarios sea esencial. Estas reservas, a menudo de pequeño tamaño, deben manejarse con pastoreo para mantener la biodiversidad, pero los efectos de regímenes específicos como el pastoreo regenerativo sobre las aves siguen siendo una incógnita en los pastizales serranos de la región Pampeana. Se evaluó la respuesta del ensamble de aves a un manejo experimental de pastoreo regenerativo comparándolo con sitios control de pastoreo tradicional y sin pastoreo en una estancia con Reserva Privada que conserva pastizales serranos de la región Pampeana en Argentina. Se registraron 36 especies de aves, incluyendo 24 generalistas de hábitat y 12 especialistas de pastizal. La abundancia de aves fue afectada por las condiciones de pastoreo. Las aves de pastizal se asociaron positivamente con el aumento de la estructura de los pastizales, mientras que las especies generalistas mostraron la respuesta opuesta. La estructura de la vegetación fue menor en la condición de pastoreo tradicional, intermedia en la condición de pastoreo regenerativo y máxima sin pastoreo. La frecuencia y el momento del pastoreo deberían permitir el descanso para garantizar una estructura vertical compleja para las aves de pastizal durante el periodo de nidificación. Métodos innovadores de manejo del pastoreo en pequeñas reservas son valiosos para el uso sostenible y la continuidad del hábitat en las Sierras de Tandilia, pero su aplicación requiere una sincronización cuidadosa para evitar comprometer el hábitat de las aves de pastizal durante la temporada de reproducción.

INTRODUCTION

Protected areas are designated geographic spaces aimed at long-term nature conservation, representing a crucial strategy to mitigate the expansion and impact of human-induced stressors on biodiversity and ecosystem services (Convention on Biological Diversity, 2023; IUCN, 1994). Globally, these areas face three main challenges: insufficient coverage across biomes, small size, and fragmentation of habitats, complicating conservation efforts (Schauman et al., 2023). Expanding the number and size and reducing levels of fragmentation of protected areas are pressing conservation challenges. In regions where land value is high, adding new public conservation areas becomes increasingly difficult. Consequently, the conservation of private lands through voluntary schemes gains importance (Kamal et al., 2015). Such initiatives significantly contribute to meeting conservation targets set by the Convention on Biological Diversity, which aims to protect at least 30 per cent of each biome (Convention on Biological Diversity, 2023; Garibaldi et al., 2020). These privately managed areas, often small and maintained by landowners, must be effectively managed to meet conservation requirements.

The Southern Grassland Biome of South America has experienced extensive agricultural development for over two centuries (Azpiroz et al., 2012). The economic value of these lands for agriculture has limited the expansion of protected areas, which currently cover less than 1 per cent of the biome's surface area (https://sifap.gob.ar/areas-protegidas). Therefore, incorporating private lands into conservation efforts presents a valuable alternative. However, managing private protected areas in grassland biomes is challenging. Grasslands evolved with natural disturbances like grazing and fire, essential for maintaining biodiversity and productivity (Paruelo et al., 2022). Without these moderating disturbances, grasslands can degrade over time, reducing biodiversity (Barzan et al., 2021; Isacch et al., 2004; Isacch & Cardoni, 2011; Isacch & Martínez, 2001; Laterra et al., 1998; Marino, 2008).

In the Pampas region of Argentina, agroecosystems have largely replaced natural grasslands, which now persist mainly in areas unsuitable for intensive agriculture (Bilenca & Miñarro, 2004). Parts of the Pampas, characterised by rocky soils, still support patches of grasslands where cattle grazing is the predominant activity. These grasslands provide crucial habitat for bird species adapted to tall grass cover. However, poorly managed grazing, which reduces grass cover from tall to short, negatively impacts specialised grassland birds (Cozzani & Zalba, 2009; Dias et al., 2017; Isacch & Cardoni, 2011; Vaccaro et al., 2020). Therefore, adopting grazing management practices that balance biodiversity conservation with agricultural production is essential (Aldabe et al., 2024; Codesido & Bilenca, 2021; Isacch & Cardoni, 2011; Marino, 2008; Pírez & Aldabe, 2023; Vaccaro et al., 2020).

Livestock grazing has been and continues to be one of the main drivers generating and maintaining grassland heterogeneity worldwide (Adler et al., 2001; Cid & Brizuela, 1998; Jacobo et al., 2006). The historically dominant herbivore in the Pampas region, the Pampas Deer (*Ozotoceros bezoarticus*), is now almost extinct due to habitat loss (Carro et al., 2019). Since organisms respond differently to the intensity of grazing, cattle grazing can functionally replace the role of native herbivores in already altered environments (Fuhlendorf & Engle, 2001). The effects of livestock grazing on grassland biodiversity dynamics are complex and often closely dependent on grazing intensity (Evans et al., 2015). While intensive grazing is detrimental to plant growth and survival, and therefore to ecosystem functioning, grazing practices that modulate the frequency, intensity and seasonality of grazing can be beneficial for biodiversity (Fuhlendorf et al., 2006; Isacch & Cardoni, 2011; Pírez & Aldabe, 2023). One such practice is regenerative grazing management in which the timing and distribution (density) of livestock grazing is carefully planned, managed and monitored with the aim of improving rangeland productivity and overall livestock system resilience (Garnett et al., 2017; Teague & Barnes, 2017). Regenerative grazing has been gaining popularity among producers and in academic circles (Giller et al., 2021; Massy, 2017). In a recent review, Morris (2021) shows evidence that regenerative grazing creates benefits for soil biota, but the evidence is not clear for other groups of organisms, especially birds, where more negative than positive effects have been reported. The contrasting evidence and the increasing uptake of this management regime require regional studies to assess the effects of regenerative grazing on different components of biodiversity. Despite growing evidence of the compatibility of grassland birds with certain grazing methods in the Pampas region (Aldabe et al., 2023; Aldabe et al., 2024; Codesido & Bilenca, 2021; Cozzani & Zalba, 2009; Dias et al., 2017; Isacch & Cardoni, 2011; Modernel et al., 2016), there are no specific studies assessing the effects of regenerative grazing on birds in this region (except for Pírez & Aldabe, 2023).

Our aim was to evaluate the bird assemblage response to an experimental regenerative grazing management approach compared to traditional grazing (almost continuous grazing on pastures with large paddocks) and control (no grazing) on the Paititi Private Natural Reserve. In 2021,

Paititi Private Natural Reserve (Tandilia Hill System, Pampas region, Argentina). One of the main management practices carried out in the reserve comprises controlled cattle grazing, to prevent fires and promote highland grasslands heterogeneity © Esteban González Zugasti.

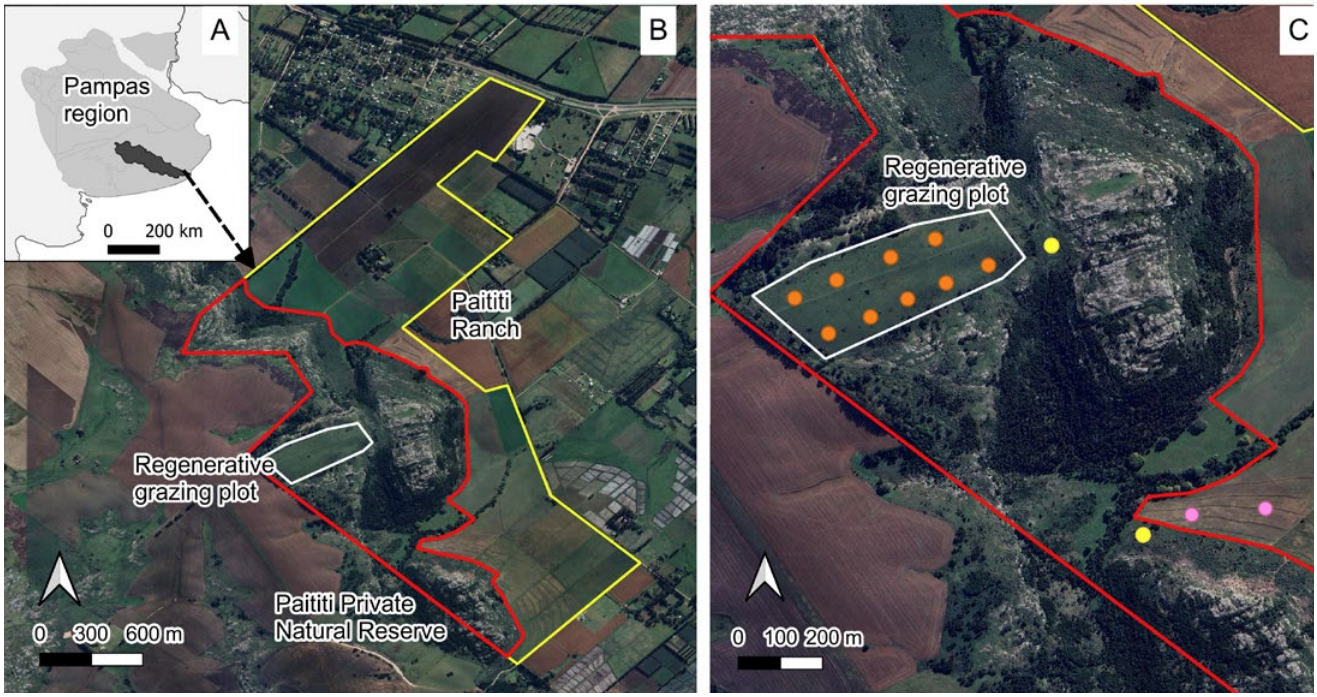


Figure 1. A- The Tandilia Hill System (dark grey area) within the Pampas Region (grey area) in Argentina. B- Location of the experimental plot with regenerative grazing (white polygon) in the Paititi Private Natural Reserve (red polygon) within the Paititi Ranch (yellow polygon). Note the agricultural matrix surrounding the reserve. C- Zoom to the study area marking the sampling points in each grazing condition (Traditional grazing: pink, Regenerative grazing: orange, Grazing exclusion: yellow).

the reserve began a regenerative grazing trial in highland grasslands to explore alternative methods for natural highland grasslands management. Our fieldwork was conducted to take advantage of this management.

STUDY AREA

The study area is in the Paititi Private Natural Reserve (37°54' S, 57°49' W) in the Southern Pampas region of Argentina within the Tandilia Hill System (Figure 1). The Tandilia System forms an arc of discontinuous elevation of approximately 1.4 million ha in the Pampas Plain. It is characterised by eroded hills (*sierras*) and small rocky outcrops (*cerrilladas*) surrounded by an undulating relief with deep soils, where agriculture is the dominant land use (Herrera et al., 2016). The average annual temperature in this region is 14°C, and the average annual precipitation is 800 mm (Burgos & Vidal, 1951). A grassland community named *flechillar* develops on the top of cerrilladas, dominated by grasses like *Nassella neesiana*, among others. There are small patches of a few hectares of mixed *pajonal* represented by *Paspalum quadrifarium*, and scattered shrubs (*Baccharis*

dracunculifolia ssp. *tandilensis*, *Colletia paradoxa* and *Dodonaea viscosa*) (Cabrera & Zardini, 1978; Echeverría et al., 2023). Grassland patches represent important biodiversity hotspots (Herrera & Laterra, 2011) especially of endemic species (Gilarranz et al., 2015; Kristensen et al., 2014), and are sources of ecosystem services (Barral & Maceira, 2012).

The Paititi Ranch, a 430 ha agricultural establishment, is in the south of this hill system (37°54' S – 57°49' W) and is part of the *Alianza del Pastizal* (Grassland Alliance), dedicated to the conservation of grasslands and its associated fauna. Within this ranch, the Paititi Reserve covers an area of 220 ha, which mainly includes the hills of the ranch, where natural grasslands and rocky communities occur. It is considered a Valuable Grassland Area (Bilenca & Miñarro, 2004), with a high value for conservation and ecotourism (Chebez, 2005), and is part of the Argentine Network of Private Nature Reserves (https://reservasprivadas.org.ar/). The main activities and management practices carried out in the reserve are environmental education for students, control of invasive species and controlled grazing to prevent fires and promote grasslands heterogeneity.

METHODS

Grazing management and sampling design

The fundamental principles of regenerative grazing are to "limit the duration of grazing to avoid regrazing of forage plants and to employ the herd effect to trample down dead plants, break up hard soil crusts, and incorporate dung, urine and plant organic matter into soils to improve soil carbon, increase water infiltration and retention, and accelerate nutrient flow for grass regrowth" (Savory & Butterfield, 2016; Teague & Barnes, 2017). This approach uses multiple small temporary paddocks that are successively stocked with large herds of livestock for a few days followed by long resting periods for vegetation recovery (many months) (Savory & Butterfield, 2016).

Regenerative grazing conditions were surveyed in a 14 ha field, where a large plot defined by permanent electric fences was successively divided by temporary electric fencing into 12 smaller temporary livestock paddocks (1.2 ha/paddock). The grazing experiment was conducted from 10 May to 31 July 2021. The rotation period averaged 6 days (SD = 2) and the stocking rate averaged 21.3 cows/ha (SD = 2.7). Two grassland patches with traditional grazing (almost continuous grazing on pastures in large paddocks) and two tall grassland patches with grazing exclusion at least two years before the experiment were included as controls (Figure 1).

Bird and vegetation surveys

We surveyed birds fortnightly to monthly between June 2021 (one month before grazing ceased) and March 2022. We used a fixed-width strip transect (100*30 m) to record the number of individuals per species (Conner & Dickson, 1980) along nine fixed transects evenly distributed within the experimental area, two fixed transects in patches with traditional grazing and two fixed transects in control patches (grasslands with grazing exclusion). Each species was classified according to habitat preference (see *Data analysis*).

We used a modification of the pole method described by Robel et al. (1970) to measure vegetation visual obstruction. In the centre of each transect we placed a 2 m pole (divided into 20 10-cm segments) and made visual obstruction readings (VOR) from a 5 m distance, with the observer's eyes at a height of 1 m (Robel et al., 1970). The height of the uppermost VOR band with ≥25 per cent vegetation cover (Toledo et al., 2010) was used as a proxy of vegetation structure.

Data analysis

We classified bird species according to habitat preference as habitat generalist or grassland specialist (Supplementary Online Material). Each species can only belong to one group, not both. This classification was adapted to the highland grassland system from personal observations and the following references: Codesido et al. (2011), Comparatore et al. (1996), Isacch and Cardoni (2011) and Pretelli et al. (2018).

To evaluate whether generalist and grassland birds varied with vegetation structure and grazing condition, we performed a Generalised Linear Mixed Model (Negative binomial family with log as the link function). We included the number of individuals (per transect) as the response variable and vegetation structure (height of the uppermost VOR band with ≥25 per cent vegetation cover), bird habitat preference (generalist or grassland specialist), grazing condition (traditional grazing, regenerative grazing, grazing exclusion) and their interactions as predictors. To account for the non-independence of repeated measurements on the same transect or date, transect ID and date were included as random factors. This approach created one value of bird abundance per date, habitat preference and transect. The model was fitted using the *glmmTMB* function from the *glmmTMB* R package (Brooks et al., 2017). We followed a model selection approach by sequentially removing non-significant terms from the original model (first the three-way interaction, then two-way interactions one by one) until no further terms could be removed (Zuur et al., 2009), based on the maximum likelihood criteria, always

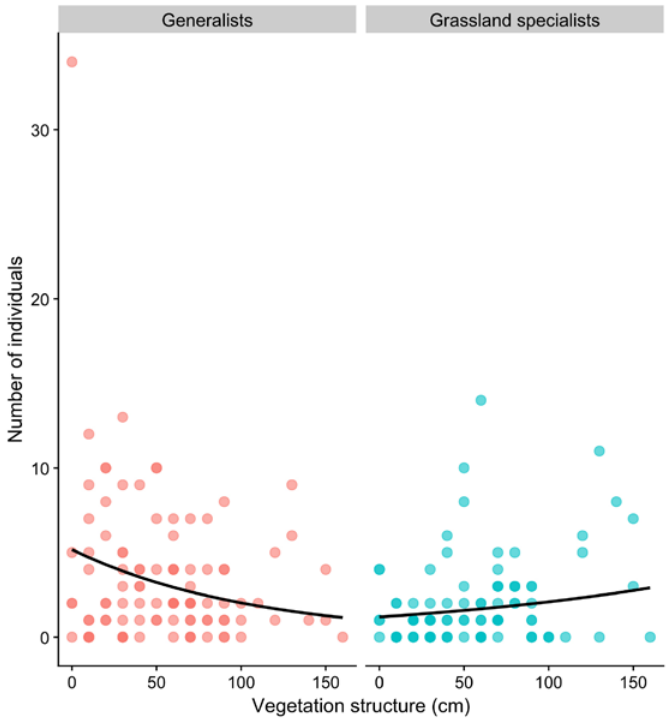


Figure 2. Bird abundance (number of individuals/transect) of generalist and grassland-specialist species in relation to vegetation structure (height of the uppermost VOR band with ≥25% cover) in highland grasslands of the Paititi Private Natural Reserve in the Tandilia Hill System. Solid lines show negative binomial GLMM predictions (95% CI omitted for clarity); darker symbols indicate overlapping points.

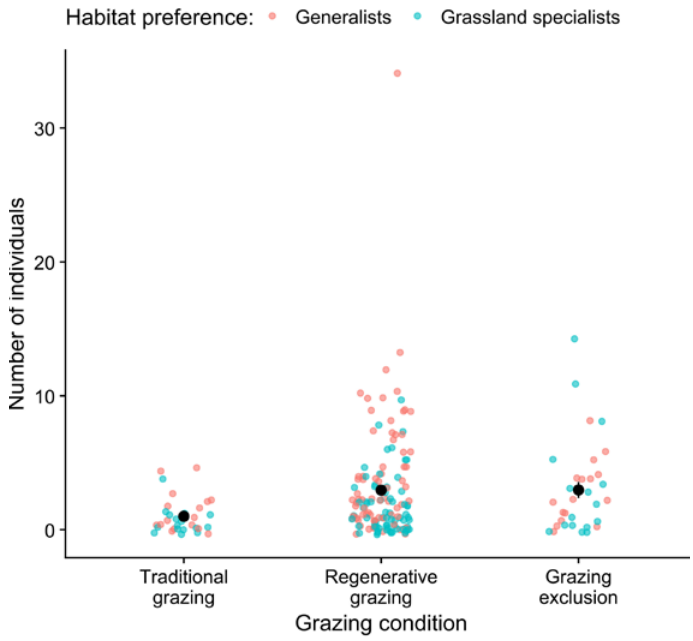


Figure 3. Bird abundance (number of individuals/transect; mean ± SE in black) across grazing conditions (traditional grazing, regenerative grazing, grazing exclusion) in highland grasslands of Paititi Private Natural Reserve, Tandilia Hill System. Smaller colored symbols represent individual values registered across the entire study (habitat generalists: coral, grassland specialists: seagreen).

Natural highland grasslands represent important biodiversity hotspots, providing crucial habitat for bird species adapted to tall grass cover. Cattle grazing is the predominant activity within these patches along the Tandilia Hill System © Esteban González Zugasti.

consistent with the AIC criterion. We evaluated the significance of individual slopes (bird abundance vs vegetation structure, either for generalists or grassland specialists) using the *emtrends* function from the *emmeans* package (Lenth, 2024). We considered temporal autocorrelation using the Ornstein–Uhlenbeck covariance structure for unevenly spaced sampling periods, but it was not significant. We also tested multicollinearity by the Variance Inflation Factor (VIF) using the *check_collinearity* function from the *performance* package (Lüdecke et al., 2021). Model assumptions were evaluated and met (Supplementary Online Material) using the *DHARMa* package (Hartig, 2024). Data management and statistical analyses were carried out using R software, version 4.3.3 (R Core Team, 2024).

RESULTS

We recorded 36 bird species across all transects with grassland specialists accounting for one third of the species (Supplementary Online Material). Bird abundance differed with vegetation structure for generalists and grassland specialists (interaction between vegetation structure and habitat preference; all statistical test results available in the Supplementary Online Material). The abundance of generalists decreased with vegetation structure, while grassland specialists tended to be more abundant in tall-grass areas (Figure 2). Bird abundance differed among grazing conditions, with fewer birds occurring in the traditional grazing management area (main effect of grazing; Figure 3). The effect of grazing condition was independent from those of other variables (i.e. interactions involving grazing condition).

Grass Wren (*Cistothorus platensis*), a typical grassland specialist bird that inhabits in tall grassland patches in the Pampas region © Tomás O'Connor.

However, the vegetation structure was lower (mean ± CI 95%: 21.9 ± 8.21) in the traditional grazing condition, intermediate (mean ± CI 95%: 53.9 ± 5.55) in the regenerative grazing condition and maximum (mean ± CI 95%: 93.8 ± 10.9) in the grazing exclusion condition (Figure 4; $\chi^2 = 79.24$, DF = 2, $p < 0.001$).

DISCUSSION

The patchy highland grasslands of the Pampas region are considered biodiversity hotspots surrounded by one of the most intensively used agricultural matrices in South America (Sabatino et al., 2010). Given the threatened nature of these grasslands, there is an urgent need to introduce grassland conservation and/or restoration, that prioritises grassland connectivity, in public and private environmental agendas. Our experiments with innovative grazing management methods in the Tandilia Hill System are useful in the search for management alternatives for these last grassland remnants (Herrera et al., 2017).

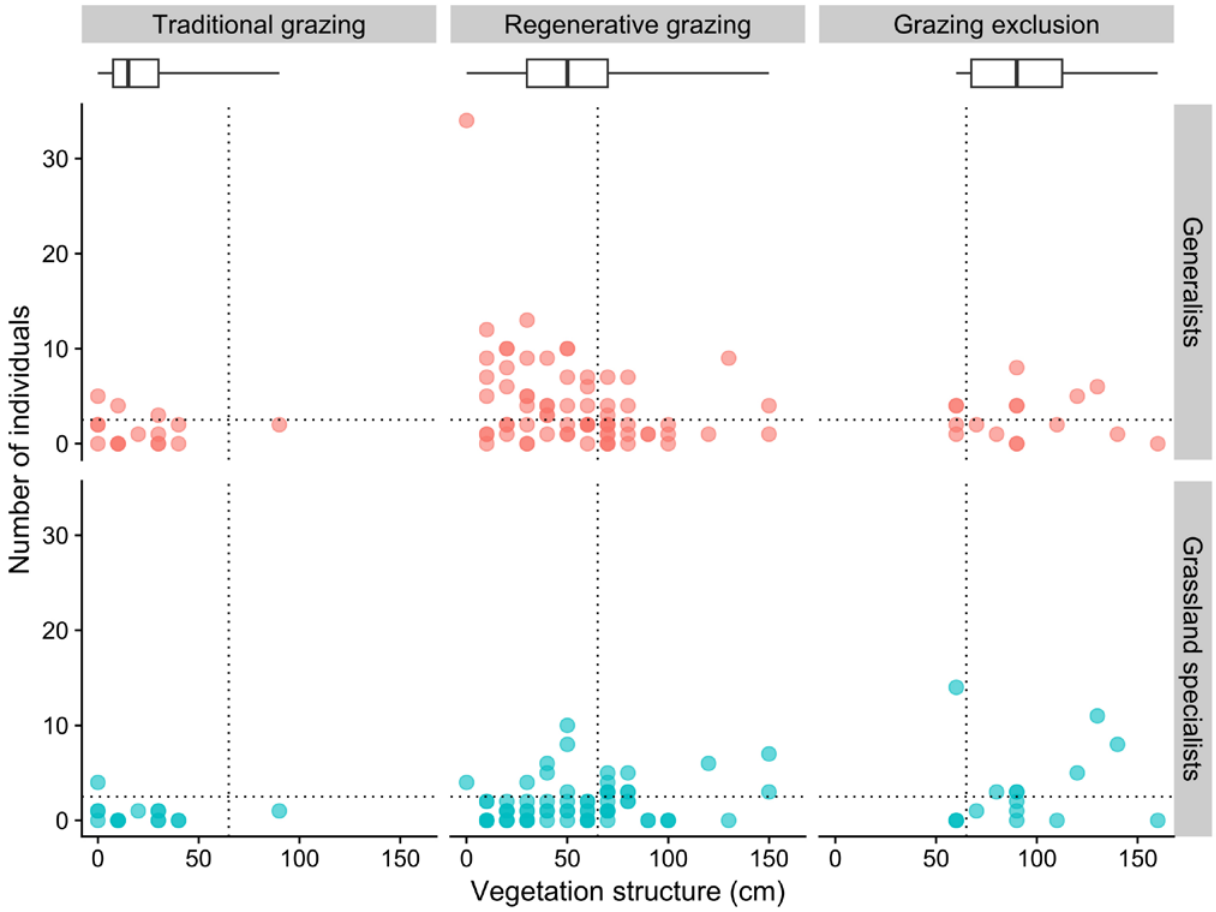
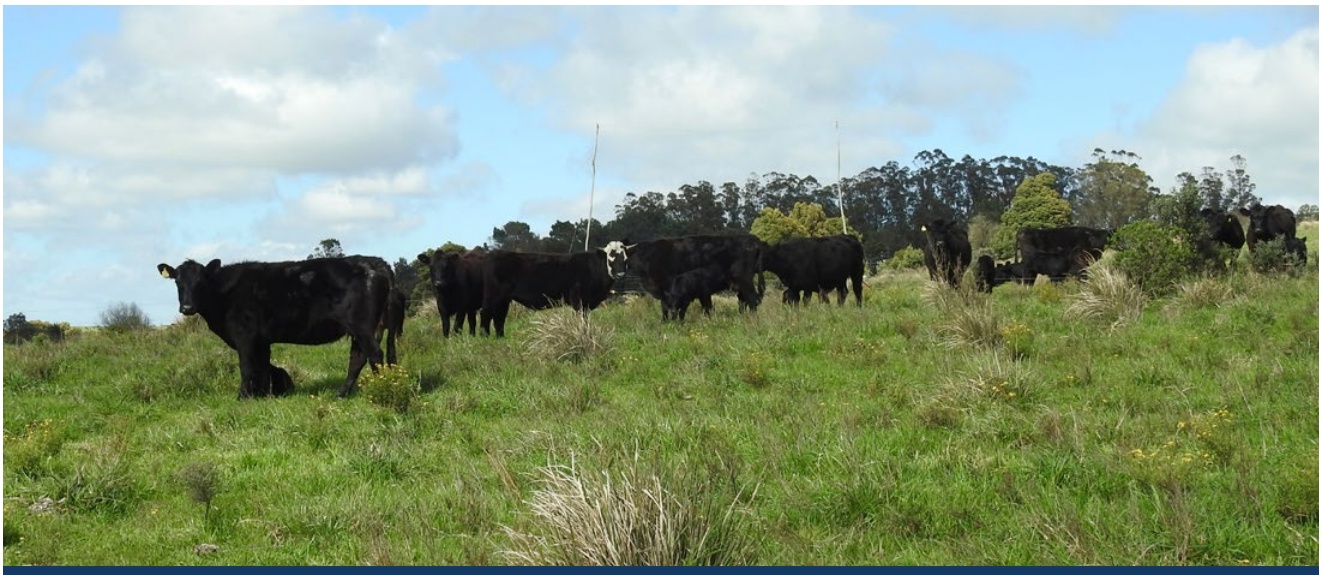


Figure 2. Bird abundance (number of individuals/transect) of generalist and grassland-specialist species in each grazing condition (traditional grazing, regenerative grazing, grazing exclusion) in relation with vegetation structure (height of the uppermost VOR band with ≥25% vegetation cover) in highland grasslands of the Paititi Private Natural Reserve, Tandilia Hill System. Darker symbols indicate overlapping points. Dotted vertical and horizontal lines are included for visual comparison across panels. Box-plots on top of the panel summarise different measurements of vegetation structure across the entire study; the central line represents the median value, the box includes all observations between quartiles 1 and 3, and whiskers depict the range of values observed in a given condition.



Cattle within one of the temporary livestock paddocks of the regenerative grazing experiment, displayed as an alternative method for natural highland grasslands management in the Paititi Private Natural Reserve, Tandilia Hill System © Juan Pablo Isacch.

Our results show that bird abundance is influenced by both vegetation structure and grazing management. Regenerative grazing maintains intermediate vegetation structure and higher bird abundance compared to traditional grazing, which shows lower vegetation and fewer birds. Bird–habitat association changed with vertical vegetation structure, since grassland specialists benefit from higher vertical structure, while generalist species decline as vertical structure increases. These patterns were recorded in other grasslands in the Pampas region, as more vulnerable pampean bird species are associated with tall grass cover (Aldabe et al., 2024; Cozzani & Zalba, 2009; Dias et al., 2017; Isacch & Cardoni, 2011). Rotation frequency should allow the grassland to rest to enable regrowth and ensure the availability of vertical structure for grassland-specialist birds (Aldabe et al., 2024; Codesido & Bilenca, 2021; Cozzani & Zalba, 2009; Dias et al., 2017; Isacch & Cardoni, 2011; Pírez & Aldabe, 2023; Vaccaro et al., 2020). In terms of bird abundance, regenerative grazing shows similar patterns to grazing exclusion. We found no evidence that grazing condition effects differed between generalists and grassland birds, hence it would be interesting to perform long-term studies with more replicates to assess this pattern focusing on the abundance of grassland birds.

In our study, grazing was mostly concentrated during autumn, leading to short grass cover that persisted until spring. Some common tall-grassland bird species can use alternative habitats such as pasturelands and croplands during the winter season (Pretelli et al., 2018), however they need tall grass cover during spring-summer to nest (Cozzani & Zalba, 2009; Pretelli et al., 2013; 2015). In this sense, regenerative grazing pulses in autumn-winter should be recommended providing sufficient time for vegetation to recover to ensure coverage of tall grasses during the birds' reproductive period (i.e. spring-summer). However, it should be considered that although structure can be adequate, there is no information about the effects of regenerative grazing on food availability for birds (i.e. insects and seeds).

Some members of the team conducting the bird census within the experimental area in the Paititi Private Natural Reserve, Tandilia Hill System © Juan Pablo Isacch.

Our study highlights certain limitations typical of this type of research: a small protected area and limited replication over time. Despite these constraints, we recognise that experimental management initiatives like ours can offer valuable insights for similar reserves characterised by small size and tall grasslands.

Globally, there is a growing interest in regenerative grazing management, which is perceived to enhance both

Anthus sp., pipit that commonly occur in grasslands and other open areas © Juan Pablo Isacch.

production and conservation outcomes (Morris, 2021). Consequently, there is a likelihood that such practices will be increasingly adopted in protected areas, especially to manage tall grasslands and mitigate fire risks. Despite the valuable insights provided by our study, we urge caution in implementing these systems more widely in small reserves due to their significant impact on grassland structure and bird diversity. Our results suggest that, with sufficient rest from grazing, plots managed under regenerative grazing can develop heterogeneity and create suitable habitat conditions for tall-grassland specialist birds. Grazing pulses should be timed to align with grassland recovery periods, ensuring availability of tall grasses during the grassland birds' breeding season (October–January; Cozzani & Zalba, 2009; Dias et al., 2017; Isacch & Cardoni, 2011; Pretelli et al., 2013; 2015).

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SUPPLEMENTARY ONLINE MATERIAL

Results tables and model assumptions.

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RÉSUMÉ

Dans les biomes de prairies du sud de l'Amérique du Sud, la valeur élevée des terres agricoles limite l'expansion des zones protégées, rendant indispensable la conservation des terres privées par le biais de programmes volontaires. Ces réserves, souvent de taille limitée, nécessitent une gestion du pâturage du bétail afin de préserver la biodiversité, mais les effets de régimes spécifiques tels que le pâturage régénératif sur les oiseaux n'ont pas encore été étudiés dans les prairies vallonnées de la région de la Pampa. Nous avons évalué la réponse de l'assemblage d'oiseaux au pâturage régénératif expérimental en le comparant au pâturage traditionnel et à des contrôles sans pâturage dans un ranch doté d'une réserve privée dans les collines de Tandilia, dans la région de la Pampa en Argentine. Nous avons recensé 36 espèces d'oiseaux, dont 24 généralistes et 12 spécialistes des prairies. L'abondance des oiseaux a été affectée par les conditions de pâturage. Les spécialistes des prairies ont été associés de manière positive à une structure accrue des prairies, tandis que les généralistes ont montré une réponse opposée. La structure de la végétation était plus faible avec le pâturage traditionnel, intermédiaire avec le pâturage régénératif et maximale sans pâturage. La fréquence et le calendrier du pâturage devraient permettre un repos afin de garantir une structure verticale complexe pour les oiseaux des prairies pendant la période de nidification. Le pâturage innovant dans les petites réserves favorise l'utilisation durable et la continuité de l'habitat dans les collines de Tandilia, mais son application nécessite un calendrier prudent afin de ne pas compromettre l'habitat des oiseaux des prairies pendant la saison de reproduction.

RESUMEN

En los biomas de pastizales del sur de Sudamérica, el alto valor de las tierras agrícolas limita la expansión de las áreas protegidas, lo que hace que la conservación en tierras privadas a través de programas voluntarios sea esencial. Estas reservas, a menudo de tamaño limitado, requieren una gestión del pastoreo del ganado para mantener la biodiversidad, pero los efectos de regímenes específicos como el pastoreo regenerativo sobre las aves siguen sin estudiarse en los pastizales de las colinas de la región pampeana. Evaluamos la respuesta de la comunidad de aves al pastoreo regenerativo experimental comparándolo con el pastoreo tradicional y los controles sin pastoreo en un rancho con una reserva privada en las colinas de Tandilia, en la región pampeana de Argentina. Registramos 36 especies de aves, entre ellas 24 generalistas del hábitat y 12 especialistas de los pastizales. La abundancia de aves se vio afectada por las condiciones de pastoreo. Las especies especialistas de los pastizales se asociaron positivamente con el aumento de la estructura de los pastizales, mientras que las generalistas mostraron la respuesta opuesta. La estructura de la vegetación fue menor con el pastoreo tradicional, intermedia con el pastoreo regenerativo y máxima sin pastoreo. La frecuencia y el momento del pastoreo deben permitir el descanso para garantizar una estructura vertical compleja para las aves de pastizales durante el período de anidación. El pastoreo innovador en pequeñas reservas favorece el uso sostenible y la continuidad del hábitat en las colinas de Tandilia, pero su aplicación requiere una sincronización cuidadosa para evitar comprometer el hábitat de las aves de pastizales durante la temporada de reproducción.