birds

MDPI

Article

Latitudinal and Seasonal Variation in Exploratory Behavior in Rufous-Collared Sparrow

Yanina Poblete [1,*], Carolina Fernández [1], Cristian R. Flores [1], Patricia Vega [1] and Miguel Ávila [2]

[1] Núcleo de Investigación en One Health (NIOH), Facultad de Medicina Veterinaria y Agronomía, Universidad de Las Américas, Campus Providencia, Manuel Montt, 948, Santiago 7500975, Chile; carofernandez@ug.uchile.cl (C.F.); cristian.floresguerra.larr@daemvaldivia.cl (C.R.F.); ptvegagarrido@gmail.com (P.V.)

[2] Núcleo de Investigación en Ciencias Biológicas (NICB), Instituto de Ciencias Naturales, Facultad de Medicina Veterinaria y Agronomía, Universidad de las Américas, Campus Providencia, Manuel Montt, 948, Santiago 7500975, Chile; mavila@udla.cl

* Correspondence: yanina.poblete@udla.cl

Simple Summary: Exploratory behavior helps animals gather information and interact with their surroundings. In seasonal environments, this behavior may vary between populations and seasons according to local context. This study examined the exploratory behavior of 102 adult rufous-collared sparrows in three locations in Chile using an open-field test. Results showed that birds tested in the Chilean central zone (33° S) and breeding birds were more exploratory than birds tested in the further south zone (38° S) and non-breeding birds, regardless of sex or body mass. These findings suggest that weather and seasonal pressures play a significant role in influencing the exploratory behavior of this species.

Abstract: Exploratory behavior involves gathering information and reflects how individuals interact with their environments. In seasonal environments, individuals undergo environmental cycles that might lead to differences in this behavior between locations and seasons. Here, we compare the exploratory behavior measured during an open-field test in 102 adult individuals of rufous-collared sparrow (*Zonotrichia capensis)* from three locations in central and southern Chile. A generalized mixed-effect model (GMM) was utilized to compare the exploratory behavior between locations and seasons. The two-way interaction between both variates was also included. Body mass and sex were included as covariates and elevation of the study sites as a random effect. The result indicates that exploratory behavior significantly varied between populations and seasons. Specifically, birds tested in the Chilean central zone (33° S) and breeding birds showed higher exploration scores during the open-field test than birds tested in the southern zone (38° S) and non-breeding birds. These findings suggest that exploratory behavior may be driven by local environmental pressures, underscoring the role of weather and seasonality in shaping this behavior.

Keywords: behavioral variability; intraspecific variation; passerines; *Zonotrichia capensis*

check for updates

Academic Editor: Jukka Jokimäki

Received: 11 February 2025
Revised: 29 April 2025
Accepted: 30 April 2025
Published: 2 May 2025

Citation: Poblete, Y.; Fernández, C.; Flores, C.R.; Vega, P.; Ávila, M. Latitudinal and Seasonal Variation in Exploratory Behavior in Rufous-Collared Sparrow. *Birds* **2025**, *6*, 24. https://doi.org/10.3390/birds6020024

Copyright: © 2025 by the authors. Licensee MDPI, Basel, Switzerland. This article is an open access article distributed under the terms and conditions of the Creative Commons Attribution (CC BY) license (https://creativecommons.org/licenses/by/4.0/).

1. Introduction

Exploratory behavior involves gathering information and reflects how individuals interact with their environments [1]. This behavior is a critical component of problem-solving, learning processes, and behavioral innovation [2]. Higher exploratory tendencies are often linked to enhanced cognitive performance and innovation, affecting various activities such as exploring new spaces, examining unfamiliar objects, and trialling new food sources [3–5]. In this context, exploratory behavior serves as both a measurable

proxy for cognitive function and a predictor of an individual's ability to adapt to changing environments or ecological challenges [6].

Exploratory behavior is linked to risk taking because it enables individuals to gather information about various environmental aspects with uncertain costs [7,8]. Some of these costs include a high risk of mortality associated with facing predators [9] and the acquisition of parasite infections [10–12]. However, evidence indicates that the risks associated with exploratory behavior vary according to local environmental conditions [13,14]. Less exploratory individuals may have an advantage in unpredictable or high-risk environments because they are generally more cautious and take fewer risks. In contrast, stable environments provide consistent resources and lower predation risks. More exploratory individuals can thrive in these conditions by discovering new resources or territories, potentially leading to greater reproductive success [15,16]. Thus, exploratory behavior helps individuals find new resources, avoid competition, and ultimately enhance their chances of survival and reproductive success [17].

Research on animal personalities indicates that exploratory behavior is a consistent and heritable trait, often linked to boldness and neophobia revised in [18]. However, early life experiences and parental care can significantly affect an individual's tendency to explore. For instance, birds raised in resource-rich environments tend to be more exploratory because they experience less stress and have more significant energy reserves for risky behaviors than those raised in poorer environments [19,20]. Exploratory behavior can also differ depending on an individual's state. This includes individual factors that can impact the trade-off between the costs and benefits of behavior, such as energy reserves, body mass, hormone levels, and immune function, among others revised in [21]. For example, Lee et al. (2016) observed that fasted Eurasian tree sparrows (*Passer montanus*) discovered more patches during the open-field test than fed sparrows [22]. Nilsson et al. (2016) found that lean blue tits (*Cyanistes caeruleus*) began exploring a novel object earlier than birds with larger fat reserves [23]. Poblete et al. (2023) found that breeding rufous-collared sparrows (*Zonotrichia capensis*) with a higher body condition index (BCI) showed higher exploratory diversity during open-field tests than birds with a lower BCI [24]. Martins et al. (2007) found that higher levels of circulating corticosterone following mild stress resulted in a higher tendency to explore and greater risk taking [25] and Jacques-Hamilton et al. (2017) found that fast explorers had lower titers of natural antibodies [26]. Factors such as age [27], social status [1], FID [28], flight initiation distance, resource availability [29], and urbanization have also been related to exploratory behavior [30]. These findings demonstrate how environmental, genetic, and individual factors modulate this behavior, highlighting its context-dependent nature [17,29].

Researchers often measure exploratory behavior using standardized tests, such as open-field tests (OFTs), where the latency to explore, the number of entries into new areas, space use, and interactions with novel objects are recorded [31–33]. OFTs provide a standardized and widely validated approach to quantify exploration in a novel environment [17,18,34]. While the test undeniably involves some degree of acute stress due to novelty and confinement, evidence shows that both between-individual and between-group variation in behavioral responses under standardized conditions of OFTs has been shown to reflect consistent personality traits across contexts, including the wild conditions revised in [18]. OFTs have shown that exploratory behavior is related to competitive foraging ability [35], foraging flexibility [31,36], greater dispersal distances [37,38], higher rates of extra-pair paternity [39], and earlier timing of breeding [40], among other functional traits revised in [18]. Exploratory behavior may be particularly informative in the context of geographic and seasonal comparisons, as it offers insight into how internal (e.g., hormonal or energetic) and external (e.g., weather conditions, parental investment, or environmental

risk) factors may modulate this behavior [41]. In seasonal environments, individuals undergo environmental cycles that result in physiological and behavioral changes [42]. For instance, during the breeding season, birds need to maximize their resource intake to fulfill the energy requirements of reproduction. This includes courtship, territory defense, nest building, egg production, and rearing chicks. On the other hand, during the non-breeding season, birds typically prioritize maintenance, survival, and energy conservation [43]. Consequently, during the breeding season, individuals may show a high exploratory tendency to find high-quality food sources and nesting sites, which may be supported by spring conditions, such as warmer temperatures and longer days [44]. Additionally, the temporary separation from the brood during experimental procedures could heighten stress levels, potentially influencing behavioral responses aimed at quickly resolving novel situations to return to the nest as soon as possible [45]. This suggests that parental investment could modulate exploration levels during this critical life-history stage [46]. Conversely, during the non-breeding season, individuals might adopt a more cautious approach to avoid predators, which could affect their exploratory behavior [47]. However, the evidence on this subject remains mixed. For instance, willow tits (*Poecile montanus*), garden warblers (*Sylvia borin*), and sardinian warblers (*Sylvia melanocephala*) exhibit reduced exploratory behavior—measured by the latency to approach novel objects—during the non-breeding season compared with the breeding season [48,49]. In contrast, grey herons (*Ardea cinerea)* and Pacific black duck (*Anas superciliosa*) show the opposite response, possibly because the increased territorial behavior and higher energy expenditure may limit exploratory behavior compared with the non-breeding season [19,50]. Additionally, previous studies in rufous-collared sparrows have shown that this behavior varies between the elevation and latitude of study sites [51,52]. Thus, the evidence suggests that exploratory behavior may vary across populations and between seasons according to local context.

Here, we characterized the exploratory behavior using an open-field test during breeding and non-breeding seasons in 102 adults of rufous-collared sparrow (Figure 1) in three populations in the center and south of Chile (Figure 2). Considering the environmental differences among these locations (Figure 3), it is reasonable to suggest that birds have developed different behavioral strategies to thrive during breeding and non-breeding seasons. We hypothesized that birds would exhibit differences in exploratory behavior among locations and show a higher exploratory tendency during the breeding season compared with the non-breeding season, due to the demands of reproduction.

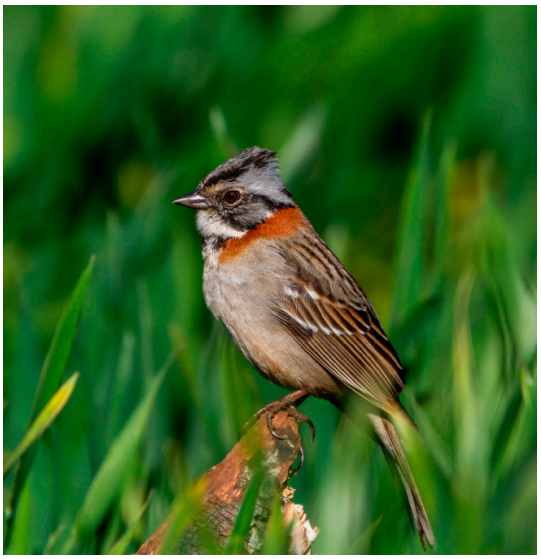

Figure 1. Figure showing an adult individual of rufous-collared sparrow. Photography by Arturo Nahun.

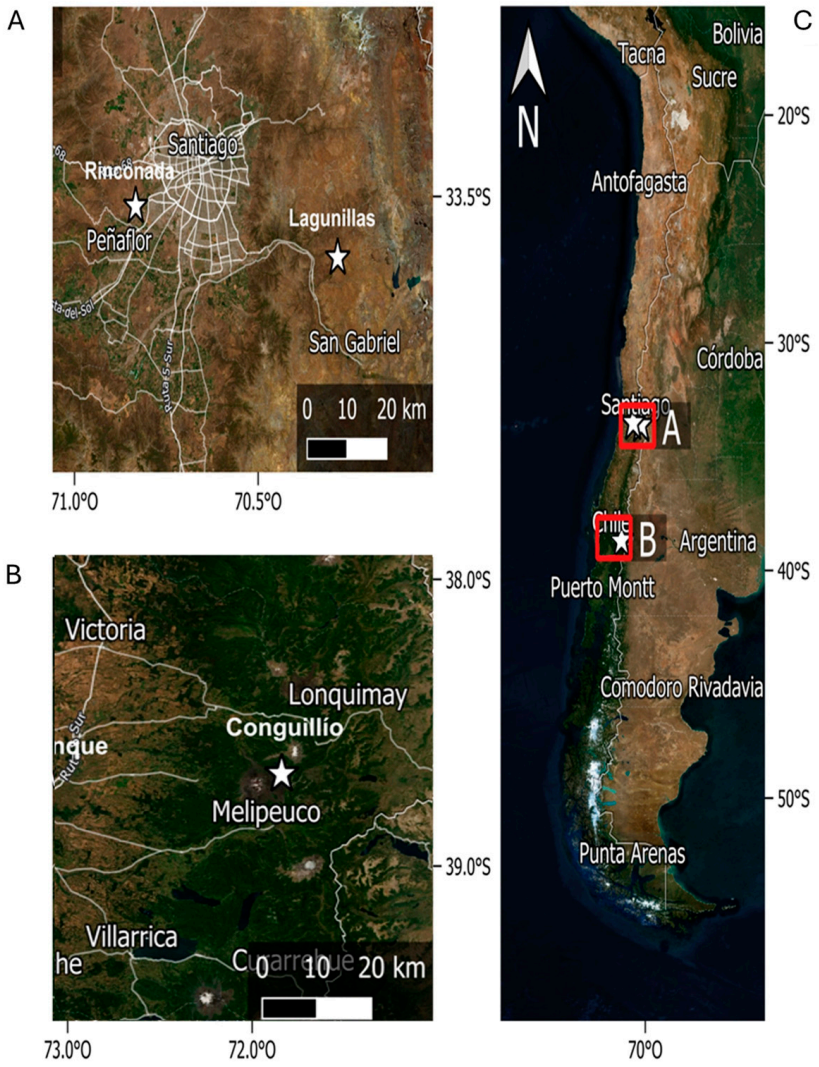

Figure 2. Figure showing the sampling locations. The left map shows the three sampled sites: Rinconada and Lagunillas in the center (**A**) and Conguillío in the south (**B**) of Chile (white stars). The right map shows the extent of the rufous-collared sparrow's distribution in the country and study sites (white stars inside red boxes;(**C**).

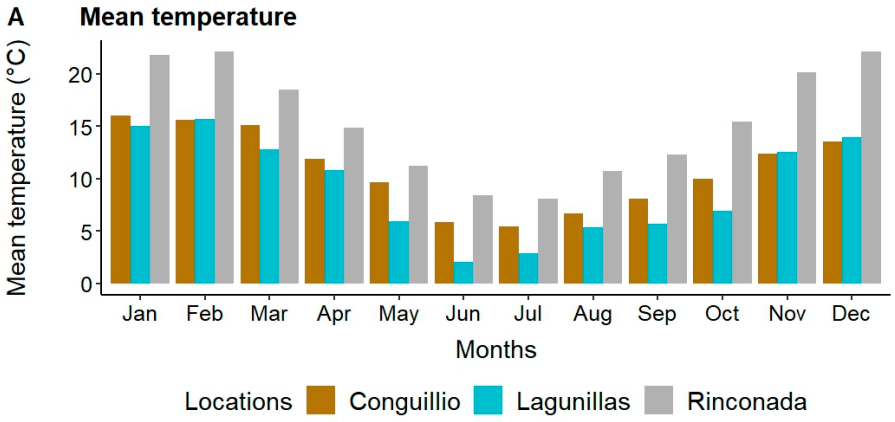

Figure 3. *Cont.*

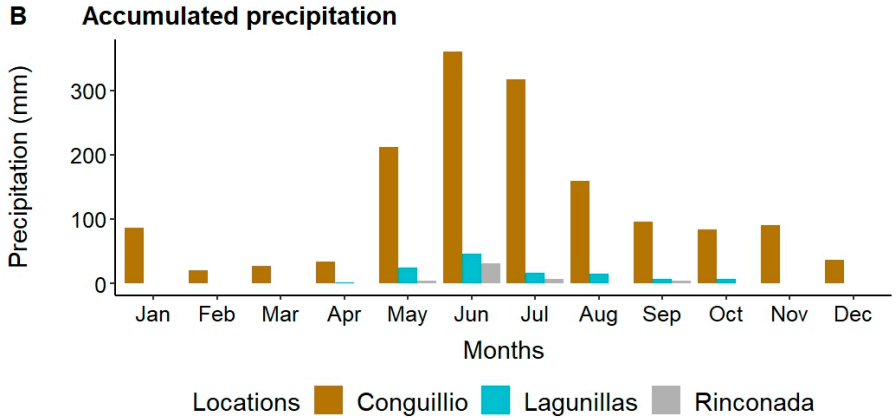

Figure 3. Figure showing the mean temperature (**A**), and accumulated precipitation in the study locations (**B**).

2. Materials and Methods

2.1. Study Species

The rufous-collared sparrow (Figure 1) is a passerine found in diverse environments, from sea level to elevations of up to 4000 m. Its habitat ranges from the southernmost point of South America (55° S) to southern Mexico (10° N), including shrublands, forest edges, agricultural landscapes, urban gardens, and high-altitude grasslands, reflecting its high ecological adaptability [53]. There are variations in behavior and physiology within the species along both latitudinal [51,52,54] and altitudinal gradients [24,55,56], including urban environments [57], showcasing their adaptability. The rufous-collared sparrow is an omnivorous species that primarily feeds on fruits, seeds, and insects [58]. Although some laboratory studies have successfully provided rufous-collared sparrows with ad libitum food through feeders in captivity [52,59], there are no available records documenting this behavior in wild populations, whether in natural or urban areas. Consequently, it remains uncertain whether this species regularly exploits predictable feeding sites in the wild. The rufous-collared sparrow appears to be socially monogamous, and both parents provide parental care by feeding nestlings and fledglings [60]. Breeding season occurs during the Austral spring and summer, from September to February, though the timing may differ among populations based on elevation and latitude [24,51]. Molting occurs from approximately January to March, while non-breeding season occurs from April to August [53]. A previous study that assessed altitudinal movement in the study population found that these populations appear to be residents, except for the Lagunillas population, which exhibits short seasonal altitudinal movements, staying above ~1000 m year-round. Furthermore, this study revealed that residency status (resident or short-distance migrant) is not associated with exploratory behavior in breeding individuals of this species [24]. The rufous-collared sparrow often forms single-species flocks, especially outside the breeding season [61].

2.2. Locations and Bird Sampling

The fieldwork was conducted in three natural areas outside urban radio, enabling the assessment of behavioral traits under seasonal and ecological conditions that more closely resemble the species' natural environment. These areas are Lagunillas (33°21′ S, 70°17′ W, 2300–2700 m s. n. m.), Rinconada de Maipú (33°31′ S, 70°50′ W, ~450 m s. n. m.), and Conguillío National Park (38°40′ S, 71°38′ W 1000–1800 m s. n. m.) in the center and south of Chile (see Figure 2). Lagunillas and Rinconada present a Mediterranean climate characterized by seasonal environmental conditions with hot summers and cold and rainy winters according to the Köppen climate classification. However, there are variations in

temperature and precipitation among these locations, influenced by elevation. On the other hand, Conguillío presents a temperate climate characterized by cold and rainy winters, with summer precipitation Figure 3 of [62].

Mist nets were used for capture adult birds during non-breeding season from April to June 2019 in Lagunillas and Rinconada de Maipú and from March to April 2020 in Conguillío. From September to December 2019 and 2020, during the breeding season, we used the same method to capture individuals in the same study sites for a total of 102 individuals (Table 1). Standardized observations recommended by Clark et al. (2019) were used to ensure a higher chance of sampling both non-breeding and breeding individuals and reducing the risk of sampling females during incubation [63]. For each bird captured, we measured their body mass with a 60 g balance scale (± 0.1 g) to be included as a covariate in the analyses (see below). Then, the birds were banded with individual metal bands (National Band and Tag Co., Newport, KY, USA and Split Metal Bird Rings, Porzana Ltd., Thetford, UK) and a small blood sample (c. 20 µL) from the brachial vein using heparinized tubes was collected. All birds were released ~20 min after their capture. The samples were stored in FTA cards (Whatman, Buckinghamshire, UK) for molecular sexing by amplifying the CHD locus using the primers 2550F (5′-GTTACTGATTCGTCTACGAGA-3′) and 2718R (5′-ATTGAAATGATCCAGTGCTTG-3′; see Supplementary Material for details) [64].

Table 1. Number of birds sampled by location, season, and sex.

Locations	Breeding		Non-Breeding		N
	Female	Male	Female	Male	
Conguillío	14	1	5	7	27
Lagunillas	7	9	9	8	33
Rinconada	5	11	16	10	42
Total	26	21	30	25	102

2.3. Open-Field Test (OFT)

The OFT is a frequently used method to assess exploratory behavior, characterized by the activity level displayed by individuals in response to novel environments or unfamiliar objects, e.g., [31–33]. Shortly after capturing the birds, OFTs were used to describe exploratory behavior. To this end, we used a field-portable aviary (270 cm long × 150 cm wide × 150 cm high; Figure 4) made of removable poles and semitransparent black cloth installed close to capture sites [51,65]. The aviary had 14 possible perching locations, including perches and walls (Figure 4). Before the trial, the birds had a five-minute acclimatization period in a small cage (30 cm long × 25 cm wide × 39 cm high; Figure 3) placed in a corner of the aviary and covered with black cloth. One minute before starting the trial, we removed this cloth, and the door of the acclimatization cage was opened for each subject to explore freely. We used a digital camera (Sony DCR-68) placed at 5–7 m from the aviary to record the behavior of each bird for 10 min [24,65,66]. All tests were conducted between 7:00 and 12:00 a.m., and birds were released at the same study sites. We analyzed the footage using J-Watcher software (Version 1.0). The frequency of visits in each of the 14 areas was used to calculate the Shannon diversity index, which indicated 'exploratory diversity' where individuals with a high Shannon index are considered more exploratory [24,67].

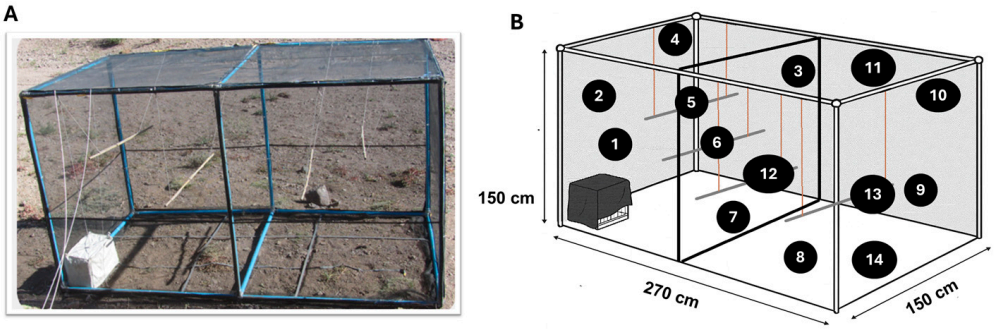

Figure 4. The portable experimental aviary used to conduct the open-field test. The acclimation cage is shown in the corner of the aviary (**A**). The numbers in the diagram indicate the potential locations used by the birds during the test, including walls, floor, ceiling, and perches (**B**).

2.4. Statistical Tests

A generalized mixed-effect model (GMM) with a Gamma error distribution and log link function were used to compare the exploratory diversity among locations and seasons. The full model included location ('Conguillío', 'Lagunillas' and 'Rinconada') and season ('breeding' or 'non-breeding') as the explanatory variables. The two-way interaction between both variables was also included. Body mass was included as a covariate, and sex ('female' or 'male') as a cofactor. Elevation of sampling locations was included as a random effect. Akaike Information Criterion was used to select the more parsimonious predictive model (AIC). We considered an effect statistically supported when $p < 0.05$. All analyses were performed in the R Studio statistical environment v.1.4.17.17 using the Base (version v. 2024.04.1) [68] and glmmTMB (version 1.1.-27.1) [69] packages.

3. Results

The most parsimonious model, based on AIC (AIC = 69.8), showed that individuals from Lagunillas and Rinconada showed significantly higher scores for the exploratory diversity (Shannon index) compared with Conguillío (Table 2; Figure 5A). Furthermore, during the breeding season, individuals exhibited significantly higher exploratory diversity scores than in the non-breeding season (Table 2; Figure 5B).

Table 2. Generalized mixed-effect models (GMM) showing the differences in exploratory behavior between both locations and seasons in rufous-collared sparrows (n = 102). The table shows the most parsimonious model based on the AIC (AIC = 69.8). Estimates, standard error (SE), z value, and *p* value are provided. See Table S2 for all additional models. Bold numbers indicate *p* value < 0.05.

Effect on Exploratory Behavior	Estimate	SE	z Value	*p*-Value
Intercept	0.316	0.048	6.45	**0.0001**
Location:Lagunillas	0.184	0.059	3.117	**0.001**
Location:Rinconada	0.118	0.056	2.101	**0.035**
Season [1]	−0.118	0.045	−2.604	**0.009**
Random effects				σ
Location				0.0001

[1] Parameter estimates and SE were estimated relative to the 'non-breeding' level in the variable season.

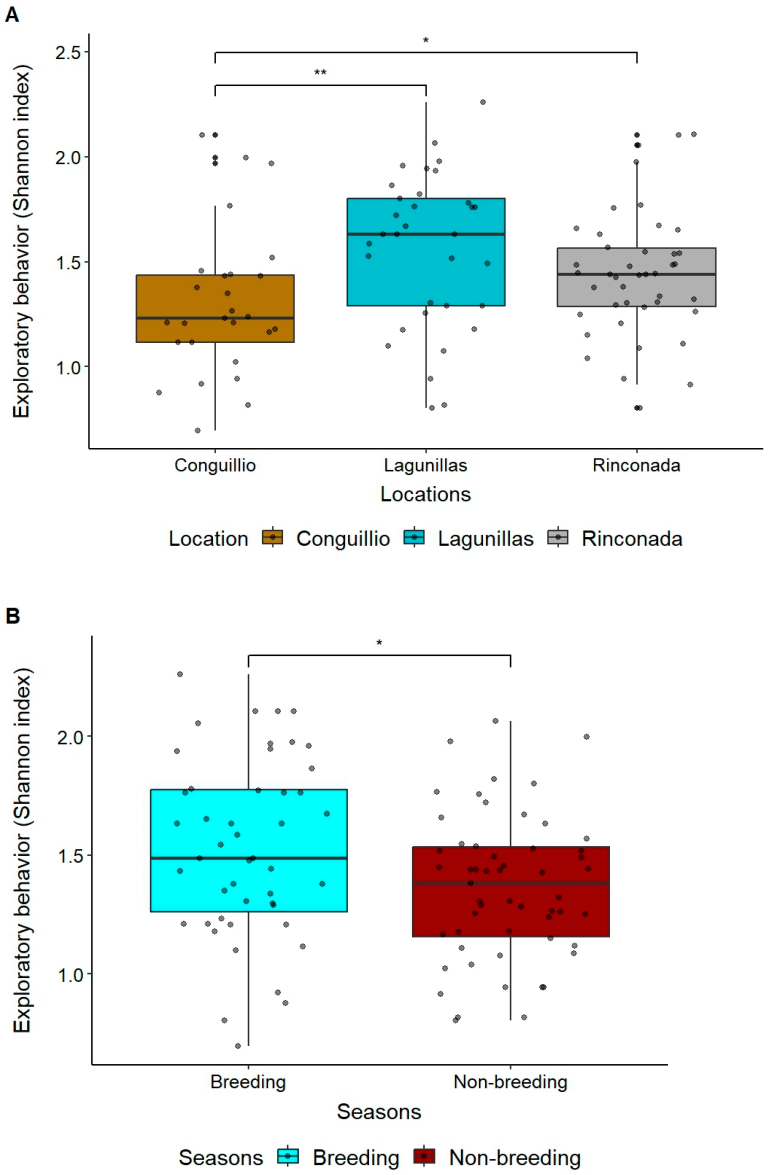

Figure 5. Differences in exploratory behavior between locations (**A**) and seasons (**B**) in rufous-collared sparrows (n = 102). The bold horizontal line inside the box represents the median score. The box limits represent 25–75%. Vertical lines indicate standard error, and asterisks indicate significant differences among groups.

4. Discussion

The results show that exploratory behavior varies among populations and between seasons. The differences in exploratory diversity observed among the rufous-collared sparrow's populations in Conguillio compared with Lagunillas and Rinconada, can be partially explained by the distinct climatic regimes characterizing these regions. Lagunillas and Rinconada are in a Mediterranean-type climate zone. Particularly, Rinconada experiences relatively high and stable mean temperatures year-round and notably lower precipitation levels. Although Lagunillas is located within the Mediterranean climatic zone of central Chile, its elevated topography (2300–2700 m s. n. m.) substantially modifies local environmental conditions [70], leading to greater climatic variability, both on a daily and seasonal scale. Lagunillas experiences much colder winters compared with lower-elevation Mediterranean sites with frequent frost and regular snow cover during the coldest months. These altitudinal effects introduce harsher and less predictable conditions, which may impose additional ecological and physiological challenges for resident bird populations [56,71,72].

As a result, previous studies on rufous-collared sparrows had reported behavioral and physiological adjustments associated with life under high elevation conditions [24,51,63,72]. Although we did not find significant differences in exploratory behavior between Lagunillas and Rinconada, a tendency toward higher exploration diversity scores was found in Lagunillas. In contrast, Conguillío exhibits a temperate and markedly wetter climate, with substantial rainfall accumulation between May and August [62]. These environmental differences likely shape behavioral strategies differently across populations. In Mediterranean environments, where resources such as food and water are often patchily distributed and subject to seasonal scarcity, individuals may benefit from adopting more diverse exploratory strategies to effectively locate and exploit these resources. Such conditions can select for behavioral flexibility and greater variation in exploration tendencies, particularly in birds inhabiting more unpredictable or heterogeneous habitats, such as Lagunillas. In contrast, the more predictable and homogeneous weather conditions of Conguillío—driven by high and sustained precipitation—may reduce the need for pronounced exploratory behavior, resulting in lower behavioral diversity [9]. Moreover, higher levels of exploration in central populations may also reflect adaptive responses to thermal and hydric constraints. Warmer and drier conditions during summer may impose greater energetic demands or foraging challenges, thereby favoring individuals that actively explore their surroundings in search of food and suitable microhabitats [16].

During the breeding season, Rufous-collared sparrows also exhibit higher exploration diversity than non-breeding season. These findings can be understood through the integration of behavioral and physiological factors. From a behavioral perspective, exploratory behavior during the breeding season is closely linked to the need to find resources, such as food and nesting sites, which directly affects reproductive success [50]. In this context, exploratory behavior may also be motivated by competition for high-quality territories or mates [40]. Individuals with higher exploration trends can locate better habitats or high-quality resources more quickly than those with fewer exploration trends [73–75]. Moreover, in a seasonal environment, breeding individuals often face increased time pressure to gather enough resources for themselves and their offspring, which requires a more active exploration strategy [40,76]. This result aligns with previous studies that show breeding individuals, particularly in territorial species like the rufous-collared sparrow, frequently expand their home ranges and increase their movements to fulfill reproductive demands [77,78]. In line with this, a key component of increased exploration in breeding adults is the role of parental care, especially in providing food for nestlings [79]. In rufous-collared sparrows, both parents are responsible for locating food to feed their offspring [53]. Provisioning requires frequent trips from the nest to foraging sites, which increases the range over which breeding adults move. This would increase mobility and exploration scores [46,80]. In contrast, non-breeding adults are not burdened by the energetic costs of parental care [43]. They do not need to forage intensively to meet the offspring's demands, allowing them to adopt a more conservative, risk-averse strategy that prioritizes energy conservation over exploratory behavior. This behavior may also reduce exposure to potential predators or environmental hazards, which is less of a concern for breeding adults whose primary focus is reproductive success [79].

The physiological state of breeding adults, particularly hormonal regulation, plays a pivotal role in exploratory behavior revised in [18]. For instance, testosterone is linked to enhanced territoriality and aggression, translating into a higher tendency to explore, as individuals seek to defend or expand their territories [81,82]. Breeding adults also experience increased metabolic demands due to the energetic costs associated with courtship, nesting, and provisioning offspring [83,84]. This heightened energetic requirement may lead to more frequent foraging trips and a need to explore new food sources. Non-breeding

adults, by contrast, are not subject to the same reproductive pressures and, therefore, may prioritize energy conservation over exploration [43]. For instance, Kresnik and Stutchbury (2014) found that wintering ovenbirds (*Seiurus aurocapilla)* exhibited different space use strategies, where short-distance wanderers tended to have higher foraging rates due to familiarity with their foraging sites, while wide-ranging wanderers may explore more but at the cost of increased energy expenditure [85]. This suggests that non-breeding adults can afford to conserve energy by remaining within familiar territories rather than seeking new food sources.

Like previous studies, differences in exploratory behavior between males and females were not found in this species [24,51]. This result may be explained by hormonal mechanisms related to testosterone (in males) and estrogen (in females). Both mechanisms can drive changes in behavior, but, if hormonal effects during the breeding season are relatively balanced between the sexes, both males and females could exhibit similar exploratory behavior. For instance, if both sexes experience elevated activity levels and metabolic demands during the breeding season due to heightened reproductive efforts, this could normalize exploratory behavior across sexes, even though their specific reproductive roles (territorial defense vs. provisioning) might differ. On the other hand, during the non-breeding season, if both sexes experience a similar reduction in reproductive hormones, their exploratory behavior might decrease as their needs shift from reproductive success to survival. Thus, exploratory behavior would remain similar between sexes in both seasons.

Generally, body mass is a proxy for an individual's energy reserves or body condition, which could influence their ability or need to explore [86]. Heavier individuals (with greater fat stores or muscle mass) might be expected to take more risks or travel farther in search of resources, especially during the breeding season when energy demands are higher [87]. Conversely, lighter individuals might be expected to conserve energy and avoid unnecessary risks [88]. However, the lack of variation in exploratory behavior with body mass suggests that exploratory tendencies in rufous-collared sparrows may not be directly linked to short-term energy stores. Exploration might be driven more by behavioral predisposition or environmental demands rather than an individual's energetic state. In other words, regardless of body mass, breeding and non-breeding adults may adopt exploratory strategies based on seasonal ecological needs rather than their current body condition.

While our results provide valuable insights into intraspecific variability in exploratory behavior across locations and seasons, several limitations must be considered when interpreting these findings. First, although we attribute some of the differences among locations to broad climatic patterns, such as temperature and precipitation regimes, our study did not explicitly quantify other local ecological factors that could influence exploratory tendencies. For instance, differences in predation pressure, food availability, and vegetation structure may contribute to behavioral differences independently or interactively with climate [9,89,90]. These unmeasured variables represent important sources of environmental heterogeneity that may shape individual behavioral strategies, and their inclusion in future research would improve the ecological characterization of each location. Additionally, it is possible that the location effect might just as well be that the birds were at a different stage of their breeding cycle. While we did not manipulate or identify individual reproductive stages (due to the use of mist nets), we avoided testing during incubation periods based on visual brood patch assessment, focusing primarily on the nestling phase, where temporary parental absence is tolerated [46].

Second, regarding seasonal variation, although higher exploratory behavior during the breeding season could reflect increased motivation to gather resources or locate nests, it

may also be influenced by stress associated with temporary separation from offspring or nesting sites during testing. Disentangling these drivers—functional versus stress-induced exploration—is inherently difficult in field-based studies. While the test undeniably involves some degree of acute stress due to novelty and confinement, such stress is intrinsic to the nature of exploration in novel environments. Here, we implemented the OFTs under strictly standardized protocols across locations and seasons (e.g., identical test aviary, time of day, immediate testing post-capture, minimal handling duration, and focusing primarily on the nestling phase) to ensure that all birds were tested under similar conditions. However, future research could integrate physiological stress indicators (e.g., baseline and stress-induced corticosterone) or manipulate parental context to better isolate the role of reproductive state from potential stress responses. Furthermore, our cross-sectional design limits our ability to assess whether observed behavioral patterns are consistent across time or if they are correlated with other behaviors, such as FID. Longitudinal studies following the same individuals across multiple seasons and years would be crucial to evaluate the temporal stability of exploratory behavior and its plasticity in response to changing environmental or life-history conditions. Such efforts are essential for understanding the adaptive significance and ecological drivers of behavioral variation in wild bird populations.

5. Conclusions

In short, rufous-collared sparrows demonstrated significant variation between latitudes, underscoring the role of weather in the modulation of this behavior. Moreover, the higher exploration scores in breeding season are likely driven by behavioral demands linked to reproductive success, such as locating food, securing nesting sites, and establishing high-quality territories. In contrast, unburdened by reproductive demands, non-breeding adults may adopt a more conservative approach to exploration, possibly prioritizing energy conservation and minimizing risk. Altogether, this result indicates that exploration may be driven by local ecological pressures, underscoring the role of latitude and seasonality in shaping the behavior of these populations.

Supplementary Materials: The following supporting information can be downloaded at: https://www.mdpi.com/article/10.3390/birds6020024/s1, DNA extraction and PCR methods; Table S1: data set of this study. Table S2: set of statistical models.

Author Contributions: Conceptualization, Y.P.; methodology, Y.P., C.F., C.R.F., P.V. and M.Á.; formal analysis, Y.P.; investigation, Y.P., C.F., C.R.F., P.V. and M.Á.; resources, Y.P.; project administration, Y.P.; funding acquisition, Y.P. All authors have read and agreed to the published version of the manuscript.

Funding: This research was funded by ANID-FONDECYT 3190111.

Institutional Review Board Statement: The study was conducted in accordance with the Declaration of Helsinki and approved by the Ethics Committee of Cicua-Comité —Universidad de Chile (19244-FCS-UCH; 2 April 2019).

Data Availability Statement: The data supporting the results are included in the article as Supplementary Material (Table S1).

Acknowledgments: We thank Javiera Pantoja, Iñigo Bidegain, Lucas Navarrete, Ernesto Gutierrez, and Gabriel Quezada for collaborating during fieldwork. Birds were captured under a Servicio Agricola Ganadero (SAG) permit.

Conflicts of Interest: The authors declare no conflicts of interest.

References

1. Dingemanse, N.J.; De Goede, P. The relation between dominance and exploratory behavior is context-dependent in wild great tits. *Behav. Ecol.* **2004**, *15*, 1023–1030. [CrossRef]
2. Auersperg, A.M.I.; Gajdon, G.K.; von Bayern, A.M.P. A new approach to comparing problem solving, flexibility and innovation. *Commun. Integr. Biol.* **2012**, *5*, 140–145. [CrossRef] [PubMed]
3. Lefebvre, L.; Reader, S.M.; Sol, D. Brains, innovations and evolution in birds and primates. *Brain Behav. Evol.* **2004**, *63*, 233–246. [CrossRef] [PubMed]
4. Jokimäki, J.; Ramos-Chernenko, A. Innovative Foraging Behavior of Urban Birds: Use of Insect Food Provided by Cars. *Birds* **2024**, *5*, 469–486. [CrossRef]
5. Mettke-Hofmann, C.; Winkler, H.; Leisler, B. The significance of ecological factors for exploration and neophobia in parrots. *Ethology* **2002**, *108*, 249–272. [CrossRef]
6. Gilmour, M.E.; Castillo-Guerrero, J.A.; Fleishman, A.B.; Hernández-Vázquez, S.; Young, H.S.; Shaffer, S.A. Plasticity of foraging behaviors in response to diverse environmental conditions. *Ecosphere* **2018**, *9*, e02301. [CrossRef]
7. Brown, C. Familiarity with the test environment improves escape responses in the crimson spotted rainbowfish, Melanotaenia duboulayi. *Anim. Cogn.* **2001**, *4*, 109–113. [CrossRef]
8. Minderman, J.; Reid, J.M.; Evans, P.G.H.; Whittingham, M.J. Personality traits in wild starlings: Exploration behavior and environmental sensitivity. *Behav. Ecol.* **2009**, *20*, 830–837. [CrossRef]
9. Réale, D.; Reader, S.M.; Sol, D.; McDougall, P.T.; Dingemanse, N.J. Integrating animal temperament within ecology and evolution. *Biol. Rev.* **2007**, *82*, 291–318. [CrossRef]
10. Poblete, Y.; Contreras, C.; Ávila, M.; Carmona, M.P.; Fernández, C.; Flores, C.R.; Sabat, P. Haemosporidian Infection Is Associated with the Oxidative Status in a Neotropical Bird. *Birds* **2024**, *5*, 604–615. [CrossRef]
11. Remacha, C.; Ramírez, Á.; Arriero, E.; Pérez-Tris, J. Haemosporidian Infections Influence Risk-Taking Behaviours in Young Male Blackcaps, Sylvia Atricapilla. *Anim. Behav.* **2023**, *196*, 113–126. [CrossRef]
12. García-longoria, L.; Garamszegi, L.Z.; Moller, A.P. Host escape behavior and blood parasite infections in birds. *Behav. Ecol.* **2014**, *25*, 890–900. [CrossRef]
13. Abbey-Lee, R.N.; Mathot, K.J.; Dingemanse, N.J. Behavioral and morphological responses to perceived predation risk: A field experiment in passerines. *Behav. Ecol.* **2016**, *27*, 857–864. [CrossRef]
14. Abbey-Lee, R.N.; Dingemanse, N.J. Adaptive individual variation in phenological responses to perceived predation levels. *Nat. Commun.* **2019**, *10*, 1601. [CrossRef]
15. Payzan-LeNestour, É.; Bossaerts, P. Do Not Bet on the Unknown Versus Try to Find Out More: Estimation Uncertainty and "Unexpected Uncertainty" Both Modulate Exploration. *Front. Neurosci.* **2012**, *6*, 31851. [CrossRef]
16. Sih, A.; Bell, A.; Johnson, J.C. Behavioral syndromes: An ecological and evolutionary overview. *Trends Ecol. Evol.* **2004**, *19*, 372–378. [CrossRef]
17. Dingemanse, N.J.; Both, C.; Drent, P.J.; Tinbergen, J.M. Fitness consequences of avian personalities in a fluctuating environment. *Proc. R. Soc. B Biol. Sci.* **2004**, *271*, 847–852. [CrossRef]
18. Carere, C.; Maestripieri, D. *Animal Personalities: Behavior, Physiology, and Evolution*; University of Chicago Press: Chicago, IL, USA, 2013.
19. McEvoy, J.F.; Roshier, D.A.; Ribot, R.F.H.; Bennett, A.T.D. Proximate cues to phases of movement in a highly dispersive waterfowl, Anas superciliosa. *Mov. Ecol.* **2015**, *3*, 13–15. [CrossRef]
20. Moyers, S.C.; Adelman, J.S.; Farine, D.R.; Moore, I.T.; Hawley, D.M. Exploratory behavior is linked to stress physiology and social network centrality in free-living house finches (Haemorhous mexicanus) Hormones and Behavior Exploratory behavior is linked to stress physiology and social network centrality in free-living. *Horm. Behav.* **2018**, *102*, 105–113. [CrossRef]
21. Sih, A.; Mathot, K.J.; Moirón, M.; Montiglio, P.O.; Wolf, M.; Dingemanse, N.J. Animal personality and state-behaviour feedbacks: A review and guide for empiricists. *Trends Ecol. Evol.* **2015**, *30*, 50–60. [CrossRef]
22. Lee, Y.F.; Kuo, Y.M.; Chu, W.C. Energy state affects exploratory behavior of tree sparrows in a group context under differential food-patch distributions. *Front. Zool.* **2016**, *13*, 48. [CrossRef] [PubMed]
23. Nilsson, A.L.K.; Nilsson, J.Å.; Mettke-Hofmann, C. Energy reserves, information need and a pinch of personality determine decision-making on route in partially migratory blue tits. *PLoS ONE* **2016**, *11*, e0163213. [CrossRef] [PubMed]
24. Poblete, Y.; Contreras, C.; Fernández, C.; Flores, C.R.; Vega, P.; Ávila, M.; Sabat, P. Geographic variation in the altitudinal migration patterns, body size, oxidative status and exploratory behavior in a neotropical bird. *Ecol. Evol.* **2023**, *13*, e9941. [CrossRef] [PubMed]
25. Martins, T.L.F.; Roberts, M.L.; Giblin, I.; Huxham, R.; Evans, M.R. Speed of exploration and risk-taking behavior are linked to corticosterone titres in zebra finches. *Horm. Behav.* **2007**, *52*, 445–453. [CrossRef]
26. Jacques-Hamilton, R.; Hall, M.L.; Buttemer, W.A.; Matson, K.D.; Gonçalves da Silva, A.; Mulder, R.A.; Peters, A. Personality and innate immune defenses in a wild bird: Evidence for the pace-of-life hypothesis. *Horm. Behav.* **2017**, *88*, 31–40. [CrossRef]

27. Biondi, L.M.; Bó, M.S.; Vassallo, A.I. Inter-individual and age differences in exploration, neophobia and problem-solving ability in a Neotropical raptor (Milvago chimango). *Anim. Cogn.* **2010**, *13*, 701–710. [CrossRef]
28. Breck, S.W.; Poessel, S.A.; Mahoney, P.; Young, J.K. The intrepid urban coyote: A comparison of bold and exploratory behavior in coyotes from urban and rural environments. *Sci. Rep.* **2019**, *9*, 2104. [CrossRef]
29. Dingemanse, N.J.; Réale, D. Natural selection and animal personality. *Behaviour* **2005**, *142*, 1159–1184. [CrossRef]
30. Biondi, L.M.; Medina, A.; Bonetti, E.A.; Paterlini, C.A.; Bó, M.S. Cognitive flexibility in a generalist raptor: A comparative analysis along an urbanization gradient. *Behav. Ecol.* **2024**, *35*, arae025. [CrossRef]
31. Verbeek, M.; Drent, P.J.; Piet, W. Consistent individual differences in early exploratory behavior of male great tits. *Anim. Behav.* **1994**, *48*, 1113–1121. [CrossRef]
32. Dingemanse, N.J.; Both, C.; Drent, P.J.; Van Oers, K.; Van Noordwijk, A.J. Repeatability and heritability of exploratory behaviour in great tits from the wild. *Anim. Behav.* **2002**, *64*, 929–938. [CrossRef]
33. Drent, P.J.; Van Oers, K.; Van Noordwijk, A.J. Realized heritability of personalities in the great tit (Parus major). *Proc. R. Soc. B Biol. Sci.* **2003**, *270*, 45–51. [CrossRef] [PubMed]
34. Hall, M.L.; van Asten, T.; Katsis, A.C.; Dingemanse, N.J.; Magrath, M.J.L.; Mulder, R.A. Animal personality and pace-of-life syndromes: Do fast-exploring fairy-wrens die young? *Front. Ecol. Evol.* **2015**, *3*, 28. [CrossRef]
35. Morgan, D.; Auclair, Y.; Giraldeuau, L.-A.; Cézilly, F. Personality and body condition have additive effects on motivation to feed in Zebra Finches Taeniopygia guttata. *Ibis* **2012**, *154*, 372–378. [CrossRef]
36. Coomes, J.R.; Davidson, G.L.; Reichert, M.S.; Kulahci, I.G.; Troisi, C.A.; Quinn, J.L. Inhibitory control, exploration behaviour and manipulated ecological context are associated with foraging flexibility in the great tit. *J. Anim. Ecol.* **2022**, *91*, 320–333. [CrossRef]
37. Dingemanse, N.J.; Both, C.; Van Noordwijk, A.J.; Rutten, A.L.; Drent, P.J. Natal dispersal and personalities in great tits (Parus major). *Proc. R. Soc. B Biol. Sci.* **2003**, *270*, 741–747. [CrossRef]
38. Botero-Delgadillo, E.; Quirici, V.; Poblete, Y.; Cuevas, É.; Kuhn, S.; Girg, A.; Teltscher, K.; Poulin, E.; Kempenaers, B.; Vásquez, R.A. Variation in fine-scale genetic structure and local dispersal patterns between peripheral populations of a South American passerine bird. *Ecol. Evol.* **2017**, *7*, 8363–8378. [CrossRef]
39. Patrick, S.C.; Chapman, J.R.; Dugdale, H.L.; Quinn, J.L.; Sheldon, B.C. Promiscuity, paternity and personality in the great tit. *Proc. R. Soc. B Biol. Sci.* **2012**, *279*, 1724–1730. [CrossRef]
40. Poblete, Y.; Botero-Delgadillo, E.; Espíndola-Hernández, P.; Vásquez, R.A. Risk-taking behaviour relates to timing of breeding in a sub-Antarctic rainforest bird. *Ibis* **2021**, *163*, 812–823. [CrossRef]
41. Royle, N.J.; Schuett, W.; Dall, S.R.X. Behavioral consistency and the resolution of sexual conflict over parental investment. *Behav. Ecol.* **2010**, *21*, 1125–1130. [CrossRef]
42. Ruf, T.; Bieber, C.; Arnold, W.; Millesi, E. *Living in a Seasonal World: Thermoregul Metab Adapt*; Springer: Berlin/Heidelberg, Germany, 2012.
43. Williams, T.D. *Physiological Adaptations for Breeding in Birds*; Princeton University Press: Princeton, NJ, USA, 2012.
44. Dawson, A.; King, V.M.; Bentley, G.E.; Ball, G.F. Photoperiodic control of seasonality in birds. *J. Biol. Rhythm.* **2001**, *16*, 365–380. [CrossRef] [PubMed]
45. Medina-García, A.; Jawor, J.M.; Wright, T.F. Cognition, personality, and stress in budgerigars, Melopsittacus undulatus. *Behav. Ecol.* **2017**, *28*, 1504–1516. [CrossRef] [PubMed]
46. Mutzel, A.; Dingemanse, N.J.; Araya-Ajoy, Y.G.; Kempenaers, B. Parental provisioning behaviour plays a key role in linking personality with reproductive success. *Proc. R. Soc. B Biol. Sci.* **2013**, *280*, 20131019. [CrossRef] [PubMed]
47. Bharucha, B.; Padate, G.S. Glycogen metabolism in a sub-tropical, social bird: White-headed jungle babbler during breeding and non-breeding states. *Biochemistry* **2005**, *14*, 234–242.
48. Lind, J.; Cresswell, W. Determining the fitness consequences of antipredation behavior. *Behav. Ecol.* **2005**, *16*, 945–956. [CrossRef]
49. Mettke-Hofmann, C. Object exploration of garden and Sardinian warblers peaks in spring. *Ethology* **2007**, *113*, 174–182. [CrossRef]
50. Vessem, J.; Draulaks, D.; Bont, A. Movements of radio-tagged Grey Herons Ardea cinerea during the breeding season in a large pond area. *Ibis* **1984**, *126*, 576–587. [CrossRef]
51. Poblete, Y.; Gutiérrez, V.; Cid, V.; Newsome, S.D.; Sabat, P.; Vasquez, R.A. Intraspecific variation in exploratory behavior and elevational affinity in a widely distributed songbird. *Oecologia* **2018**, *186*, 931–938. [CrossRef]
52. Maldonado, K.; van Dongen, W.F.D.; Vásquez, R.; Sabat, P. Geographic variation in the association between exploratory behavior and physiology in rufous-collared sparrows. *Physiol. Biochem. Zool.* **2012**, *85*, 618–624. [CrossRef]
53. Chapman, F.M. The Post-Glacial History of Zonotrichia capensis. *Bull. Am. Mus. Nat. Hist.* **1940**, *78*, 381–438.
54. Sabat, P.; Gonzalez-Vejares, S.; Maldonado, K. Diet and habitat aridity affect osmoregulatory physiology: An intraspecific field study along environmental gradients in the Rufous-collared sparrow. *Comp. Biochem. Physiol. A Mol. Integr. Physiol.* **2009**, *152*, 322–326. [CrossRef] [PubMed]
55. Ruiz, G.; Novoa, F.F.; Sabat, P. Hematological parameters and stress index in Rufous-collared Sparrows dwelling in urban environments. *Condor* **2002**, *104*, 162–166. [CrossRef]

56. Poblete, Y.; Gutierrez, V.; González, P.L.; Wingfield, J.C.; Vásquez, R.A. Differences in circulating corticosterone levels associated with elevation of breeding sites in Rufous-collared Sparrows Zonotrichia capensis. *J. Ornithol.* **2020**, *162*, 487–496. [CrossRef]
57. Fernández, C.; Villaseñor, N.R.; Contreras, C.; Ávila, M.; Sabat, P.; Poblete, Y. Intra-urban variation in body condition, body size and oxidative status of Rufous-collared sparrow relate to urban green space attributes in a Latin American metropolis. *Urban Ecosyst.* **2023**, *26*, 575–586. [CrossRef]
58. Lopez-Calleja, M.V. Dieta de Zonotrichia capensis (Emberizidae) Y Diuca diuca (Fringillidae): Efecto de la variación estacional de los recursos tróficos y la riqueza de aves granívoras en Chile central. *Rev. Chil. Hist. Nat.* **1995**, *68*, 321–331.
59. Van Dongen, W.F.D.; Maldonado, K.; Sabat, P.; Vásquez, R.A. Geographic variation in the repeatability of a personality trait. *Behav. Ecol.* **2010**, *21*, 1243–1250. [CrossRef]
60. Miller, A.H.; Miller, V.D. The behavioral ecology and breeding biology of the andean sparrow, Zonotrichia Capensis The behavioral ecology and breeding biology of the andean sparrow, Zonotrichia Capensis. *Caldasia* **1968**, *10*, 83–154.
61. Rubenstein, D.I.; Barnett, R.J.; Ridgely, R.S.; Klopfer, P.H. Adaptive advantages of mixed-species feeding flocks among seed-eating finches in Costa Rica. *Ibis* **1977**, *119*, 10–21. [CrossRef]
62. Peel, M.C.; Finlayson, B.L.; McMahon, T.A. Updated world map of the K¨oppen-Geiger climate classificatio. *Hydrol. Earth Syst. Sci.* **2007**, *11*, 1633–1644. [CrossRef]
63. Clark, A.D.; Addis, E.A.; Vásquez, R.A.; Wingfield, J.C. Seasonal modulation of the adrenocortical stress responses in Chilean populations of Zonotrichia capensis. *J. Ornithol.* **2019**, *160*, 61–70. [CrossRef]
64. Fridolfsson, A.K.; Ellegren, H. A simple and universal method for molecular sexing of non-ratite birds. *J. Avian Biol.* **1999**, *30*, 116–121. [CrossRef]
65. Botero-delgadillo, E.; Quirici, V.; Poblete, Y.; Poulin, E.; Kempenaers, B.; Vásquez, R.A. Exploratory behavior, but not aggressiveness, is correlated with breeding dispersal propensity in the highly philopatric thorn-tailed rayadito. *J. Avian Biol.* **2020**, *51*, 1–12. [CrossRef]
66. Poblete, Y.; Cuevas, É.; Botero-Delgadillo, E.; Espíndola-Hernández, P.; Quirici, V.; Vásquez, R.A. Risk-taking behavior relates to Leucocytozoon spp. infection in a sub-Antarctic rainforest bird. *Acta Ethol.* **2024**, *27*, 113–123. [CrossRef]
67. Blumstein, D.T.; Daniel, J.C. *Quantifying Behavior the JWatcher Way*; Sinauer Associates: Sunderland, MA, USA, 2007.
68. RStudio Team. *RStudio: Integrated Development Environment for R*; RStudio Team: Boston, MA, USA, 2024.
69. Brooks, M.; Bolker, B.; Kristensen, K.; Maechler, M.; Magnusson, A.; McGillycuddy, M.; Skaug, H.; Nielsen, A.; Berg, C. glmmTMB: Generalized Linear Mixed Models Using Template Model Builder (R Package Version 1.7). 2023. Available online: https://cran.r-project.org/package=glmmTMB (accessed on 1 February 2025).
70. Vranken, S.; Wernberg, T.; Scheben, A.; Severn-Ellis, A.A.; Batley, J.; Bayer, P.E.; Edwards, D.; Wheeler, D.; Coleman, M.A. Genotype–Environment mismatch of kelp forests under climate change. *Mol. Ecol.* **2021**, *30*, 3730–3746. [CrossRef] [PubMed]
71. Körner, C. The use of "altitude" in ecological research. *Trends Ecol. Evol.* **2007**, *22*, 569–574. [CrossRef]
72. Poblete, Y.; Contreras, C.; Fernández, C.; Ávila, M.; Sabat, P. Altitudinal variation in oxidative status between breeding and non-breeding seasons in a Neotropical bird. *J. Ornithol.* **2025**. [CrossRef]
73. Wirowska, M.; Iwińska, K.; Borowski, Z.; Brzeziński, M.; Solecki, P.; Boratyński, J.S. Does Explorative Behavior Allow the Successful Finding of Ephemeral Food Resources in the Wild? *Mammal Res.* **2023**, *69*, 89–98. [CrossRef]
74. Smith, J.B.; Keiter, D.A.; Sweeney, S.J.; Miller, R.S.; Schlichting, P.E.; Beasley, J.C. Habitat Quality Influences Trade-Offs in Animal Movement Along the Exploration–exploitation Continuum. *Sci. Rep.* **2023**, *13*, 4814. [CrossRef]
75. Boon, A.K.; Réale, D.; Boutin, S. The interaction between personality, offspring fitness and food abundance in North American red squirrels. *Ecol. Lett.* **2007**, *10*, 1094–1104. [CrossRef]
76. Verhulst, S.; Nilsson, J.Å. The timing of birds' breeding seasons: A review of experiments that manipulated timing of breeding. *Philos. Trans. R. Soc. B Biol. Sci.* **2008**, *363*, 399–410. [CrossRef]
77. Williams, H.; Willemoes, M.; Klaassen, R.H.G.; Strandberg, R.; Thorup, K. Common Cuckoo Home Ranges Are Larger in the Breeding Season Than in the Non-Breeding Season and in Regions of Sparse Forest Cover. *J. Ornithol.* **2015**, *157*, 461–469. [CrossRef]
78. Mwangi, J.; Klaassen, R.H.G.; Muchai, M.; Tieleman, B.I. Home-ranges of Tropical Red-capped Larks Are Influenced by Breeding Rather Than Vegetation, Rainfall or Invertebrate Availability. *Ibis* **2019**, *162*, 492–504. [CrossRef]
79. Gross, M.R. The evolution of parental care. *Q. Rev. Biol.* **2005**, *80*, 37–45. [CrossRef] [PubMed]
80. David, M.; Pinxten, R.; Martens, T.; Eens, M. Exploration behavior and parental effort in wild great tits: Partners matter. *Behav. Ecol. Sociobiol.* **2015**, *69*, 1085–1095. [CrossRef]
81. Moss, R.L.; Parr, R.; Lambin, X. Effects of Testosterone on Breeding Density, Breeding Success and Survival of Red Grouse. *Proc. R. Soc. B Biol. Sci.* **1994**, *258*, 175–180. [CrossRef]
82. Apfelbeck, B.A.; Flinks, H.; Goymann, W. Variation in Circulating Testosterone During Mating Predicts Reproductive Success in a Wild Songbird. *Front. Ecol. Evol.* **2016**, *128*, 104900. [CrossRef]

83. Bevan, R.M.; Butler, P.J.; Woakes, A.J.; Boyd, I.L. The Energetics of Gentoo Penguins, *Pygoscelis Papua*, During the Breeding Season. *Funct. Ecol.* **2002**, *16*, 175–190. [CrossRef]
84. Fayet, A.L.; Freeman, R.; Anker-Nilssen, T.; Diamond, A.W.; Erikstad, K.E.; Fifield, D.; Fitzsimmons, M.G.; Hansen, E.S.; Harris, M.; Jessopp, M.; et al. Ocean-Wide Drivers of Migration Strategies and Their Influence on Population Breeding Performance in a Declining Seabird. *Curr. Biol.* **2017**, *27*, 3871–3878.e3. [CrossRef]
85. Kresnik, R.J.; Stutchbury, B.J.M. Space-Use Strategies of Wintering Ovenbirds in Belize: Causes and Consequences. *J. Field Ornithol.* **2014**, *85*, 274–288. [CrossRef]
86. Labocha, M.K.; Hayes, J.P. Morphometric indices of body condition in birds: A review. *J. Ornithol.* **2012**, *153*, 1–22. [CrossRef]
87. Smith, R.J.; Moore, F.R. Arrival Fat and Reproductive Performance in a Long-Distance Passerine Migrant. *Oecologia* **2003**, *134*, 325–331. [CrossRef] [PubMed]
88. Salewski, V.; Schaub, M. Stopover Duration of Palearctic Passerine Migrants in the Western Sahara—Independent of Fat Stores? *Ibis* **2007**, *149*, 223–236. [CrossRef]
89. Carere, C.; Drent, P.J.; Koolhaas, J.M.; Groothuis, T.G.G. Epigenetic effects on personality traits: Early food provisioning and sibling competition. *Behaviour* **2005**, *142*, 1329–1355. [CrossRef]
90. Bell, A.M. Behavioural differences between individuals and two populations of stickleback (Gasterosteus aculeatus). *J. Evol. Biol.* **2005**, *18*, 464–473. [CrossRef]

Disclaimer/Publisher's Note: The statements, opinions and data contained in all publications are solely those of the individual author(s) and contributor(s) and not of MDPI and/or the editor(s). MDPI and/or the editor(s) disclaim responsibility for any injury to people or property resulting from any ideas, methods, instructions or products referred to in the content.