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Photographic surveys reveal site-specific differences in age structure and age-specific lesion prevalence in overwintering Black-chested Buzzard-Eagles (*Geranoaetus melanoleucus*) in Patagonia

Matías A. Juhant[a] and Miguel D. Saggese[b]

[a]Acopian Center for Conservation Learning, Hawk Mountain Sanctuary, Orwigsburg, PA, USA; [b]College of Veterinary Medicine, Western University of Health Sciences, Pomona, CA, USA

ABSTRACT

Understanding patterns of abundance and anthropogenic-induced stressors in free-ranging raptors remains challenging due to the difficulty of assessing both abundance and the occurrence of physical lesions in the same populations. However, field photography offers a practical, non-invasive approach to evaluate these traits at specific sites. We conducted 209 h of observation and photographic surveys over four austral winters at two anthropogenic food-rich sites separated by 1,750 km in Argentine Patagonia. We assessed the number of individuals, age structure, and age-specific lesion types and prevalence in overwintering Black-chested Buzzard-Eagles (*Geranoaetus melanoleucus*). We found that: (1) a minimum of 394 individuals overwintered at these sites; (2) the age structure of counted individuals differed markedly between sites and across time periods, with the northern site (surveyed in 2022 and 2023) slightly skewed toward younger age classes, whereas the southern site (surveyed in 2014 and 2016) was strongly dominated by the oldest age class; (3) 22% (86 of 394 individuals) exhibited lesions, primarily affecting the hindlimbs (e.g. missing legs, digits or talons, and swollen tarsometatarsus-digits joint or digits); (4) among the 86 affected individuals, a total of 102 lesions were documented, yielding a ratio of 1.19 lesions per individual; (5) lesion prevalence was more than twice as high at the southern site (60 of 191 individuals; 31%) compared to the northern site (26 of 203 individuals, 13%); and (6) swollen tarsometatarsus-digits joint or digits was the most prevalent lesion type at both sites, showing no differences among age classes at the northern site, whereas at the southern site it was significantly higher in the oldest age class. Together, these results indicate potential site- or year-specific differences in age structure and age-specific lesion prevalence in overwintering Black-chested Buzzard-Eagles in Patagonia.

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Address correspondence to Matías A. Juhant. E-mail: juhant@hawkmountain.org

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Muestreos fotográficos revelan diferencias específicas entre sitios en la estructura etaria y en la prevalencia de lesiones por clase de edad en águilas moras (*Geranoaetus melanoleucus*) invernando en la Patagonia

RESUMEN

Comprender los patrones de abundancia y estresores antropogénicos en rapaces en libertad sigue siendo un desafío debido a la dificultad de evaluar simultáneamente la abundancia y la presencia de lesiones físicas en las mismas poblaciones. Sin embargo, la fotografía de campo ofrece un enfoque práctico y no invasivo para evaluar estos rasgos en sitios específicos. Realizamos 209 h de observación y muestreos fotográficos durante cuatro inviernos australes en dos sitios de origen antropogénico con alta abundancia de alimento, separados entre sí por 1,750 km en la Patagonia Argentina. Evaluamos el número de individuos, la estructura etaria, los tipos de lesiones y su prevalencia según clase de edad en águilas moras (*Geranoaetus melanoleucus*) invernando en estos sitios. Encontramos que: (1) un mínimo de 394 individuos invernaron en estos sitios; (2) la estructura etaria de los individuos registrados difirió marcadamente entre sitios y períodos, con el sitio norte (muestreado en 2022 y 2023) ligeramente sesgado hacia clases de edad más jóvenes, mientras que el sitio sur (muestreado en 2014 y 2016) estuvo fuertemente dominado por la clase de mayor edad; (3) el 22% (86 de 394 individuos) presentó lesiones, afectando principalmente las extremidades posteriores (e.g., amputación de patas, dedos o garras, y articulaciones inflamadas del tarso-metatarso-dedos o de los dedos); (4) entre los 86 individuos afectados se documentaron un total de 102 lesiones, lo que representa una proporción de 1.19 lesiones por individuo; (5) la prevalencia de lesiones fue más del doble en el sitio sur (60 de 191 individuos; 31%) en comparación con el sitio norte (26 de 203 individuos; 13%); y (6) las articulaciones inflamadas del tarso-metatarso-dedos o de los dedos fueron el tipo de lesión más frecuente en ambos sitios, sin diferencias entre clases de edad en el sitio norte, mientras que en el sitio sur fueron significativamente más frecuentes en la clase de mayor edad. En conjunto, estos resultados indican posibles diferencias específicas de sitio y/o de año en la estructura etaria y en la prevalencia de lesiones según clase de edad en águilas moras invernando en la Patagonia.

In the digital era, field photography has significantly expanded the scope of wildlife conservation research by enabling documentation of physical injuries and their prevalence, proving particularly effective for free-living terrestrial and marine mammals (Muneza et al. 2019; Toms et al. 2020; Feyrer et al. 2021). In contrast, comparable data for free-ranging avian predators, such as raptors, remain scarce. Most current knowledge on morbidity and mortality of free-ranging raptors is derived from individuals admitted to rehabilitation centers (Molina-López et al. 2011; Montesdeoca et al. 2016; Cococcetta et al. 2022; Gomez et al. 2023). In contrast, few studies describe the prevalence of physical lesions (abnormal changes in the structure of an organ resulting from physical damage and often of uncertain

origin; hereafter "lesions") in free-ranging individuals captured during banding procedures (Dwyer 2006; Bedrosian and St. Pierre 2007; Holt and Layne 2008). However, recent advances in field photography have provided a valuable tool for assessing raptor abundance (Juhant et al. 2022) and documenting lesions in free-ranging raptors (Juhant et al. 2024; Juhant 2026). This non-invasive tool can bridge key knowledge gaps regarding the prevalence of lesions, potentially even enabling early detection of emerging threats to raptor populations.

For raptors, damage to the beak, wings, or legs can impair prey capture efficiency and competitive ability, reducing hunting success, energy intake, and ultimately key fitness components such as body condition, reproduction, and survival (Durham 1981; Rodríguez-Díez et al. 2020; Orosz et al. 2023). When widespread, individual-level impairments can scale up to population-level effects through increased, and often age-specific, mortality and reduced recruitment (Newton 2008); consequently, assessing age structure and lesion prevalence across age classes is critical for identifying cohort-specific vulnerabilities that may compromise population resilience and long-term viability (Cristol et al. 1999; Newton 2008). This can be particularly true for anthropogenic-induced stressors, whose prevalence appears non-randomly distributed within populations, affecting many individuals at one location (Dwyer 2006; Bedrosian and St. Pierre 2007; Juhant et al. 2024).

In Patagonia (37–56°S), the southernmost region of South America, the Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*) stands out as the most abundant and the largest top avian predator and facultative scavenger (Ferguson-Lees and Christie 2001, Juhant and Saggese pers. obs.). This species exhibits delayed plumage maturation, characterized by five distinctive age classes that can be identified through direct observation and photographic records (Seipke 2007; Juhant et al. 2022). It is also a partial migrant within the Austral-Neotropical system, breeding in the Southern Cone of South America and overwintering at temperate latitudes or at the tropical belt (Juhant 2022; Juhant et al. 2022). Given its historical vulnerability to anthropogenic-induced stressors (De Lucca and Saggese 1989; Hiraldo et al. 1995; Saggese and De Lucca 2001; Ibarra and De Lucca 2015; Juhant et al. 2024) and its tendency to congregate during winter in areas where food becomes temporarily and predictably concentrated, the Black-chested Buzzard-Eagle is an ideal species for analyzing overwintering numbers, age structure, and age-specific lesion types and prevalence.

Here, we surveyed winter congregations of Black-chested Buzzard-Eagles during the austral winter at two anthropogenic food-rich sites located 1,750 km apart. Specifically, we aimed to: (1) quantify the minimum number of overwintering individuals; (2) compare age structure across years within sites, despite among-site differences arising from temporal mismatches in sampling; (3) quantify age-specific lesion types and their prevalence; and (4) evaluate whether lesion prevalence varied among age classes within each site. A portion of this dataset (spanning three austral winters) was previously published in Juhant et al. (2024) and focused on the occurrence of lesions and mortality events across multiple species of the scavenger raptor guild. The expanded dataset presented here encompasses four austral winters, two at each site over a nine-year time period, and focuses exclusively on the Black-chested Buzzard-Eagle, allowing a detailed, species-specific assessment of overwintering numbers, age structure, and age-specific lesion types and prevalence.

Methods

Study sites

We conducted fieldwork at two open-sky anthropogenic food-rich sites in Argentine Patagonia during August (austral winter; Fig. 1). We selected these study sites based on previous third-party observations indicating significant congregations of obligate and facultative scavenger raptors (Fig. 2). The northern site, situated near Cipolletti, Río Negro Province (38°54′01″S, 67°53′58″W), is a disposal site for chicken carcasses. Shrub patches, human-made posts, and electrical transmission lines provide perches for individuals feeding at the site. The southern site, situated near Ushuaia, Tierra del Fuego Province (54°47′31″S, 68°13′13″W), is a landfill used for municipal waste disposal. Patches of forest, and human-made posts provide perches for individuals feeding at the site. All fieldwork was conducted between 0900–1600 h Argentina Standard Time (GMT-3).

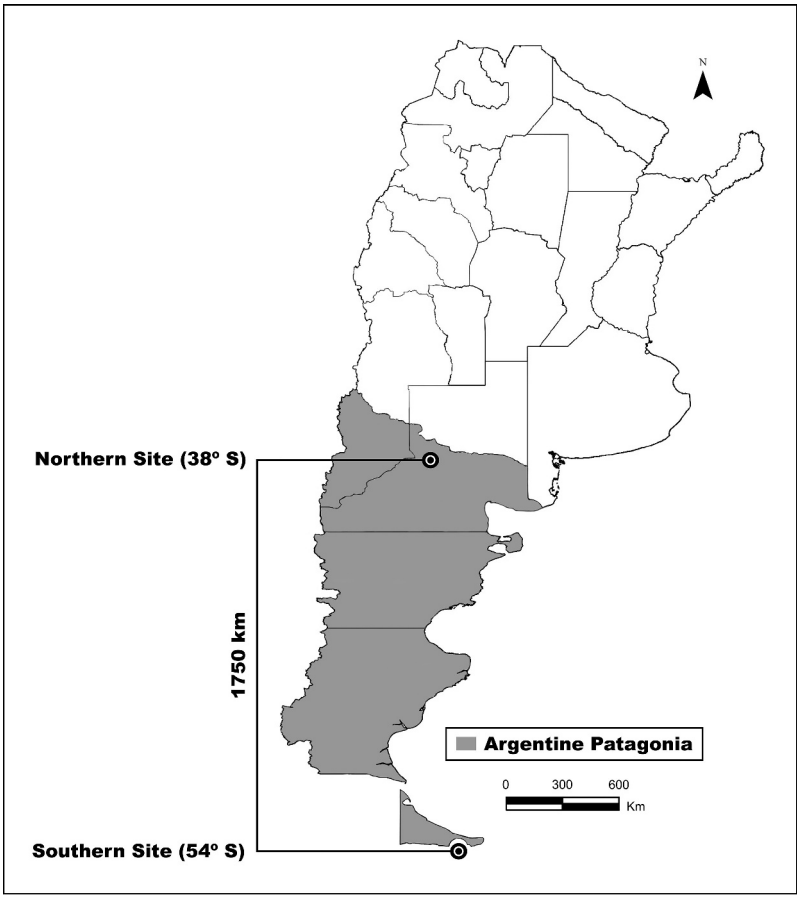


Figure 1. Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*) overwintering at two anthropogenic food-rich sites in Argentine Patagonia: the northern site (surveyed in 2022 and 2023) in Cipolletti, Río Negro Province, and the southern site (surveyed in 2014 and 2016) in Ushuaia, Tierra del Fuego Province.



Figure 2. Black-chested Buzzard-Eagles (*Geranoaetus melanoleucus*) and other facultative scavenger species foraging and feeding at two anthropogenic food-rich sites in Argentine Patagonia. (A) Black-chested Buzzard-Eagles, Chimango Caracara (*Daptrius chimango*), and Crested Caracara (*Caracara plancus*) at the northern site. (B) A small group of Black-chested Buzzard-Eagles of different age classes at the northern site, including a Basic II individual holding an entire chicken leg. (C) Black-chested Buzzard-Eagles, Chimango Caracara, Crested Caracara, White-throated Caracara (*Daptrius albogularis*), and Kelp Gull (*Larus dominicanus*) at the southern site. Photos by Matías A. Juhant.

Individual identification based on the appearance of flight feathers and color traits

We photographed every detected Black-chested Buzzard-Eagle either perching or flying (most often both) at distances of up to 300 m using a Canon EOS 7 D with a Canon EF 400 mm f/5.6 L lens (2014 and 2016; southern site) and a Canon EOS 7 D Mark II with

a Canon EF 400 mm f/4.0 L lens (2022 and 2023; northern site). Individual specific field marks allowed reliable individual identification, preventing double-counting of the same individual within each austral winter.

The Black-chested Buzzard-Eagle shows high variability in the patterns of its non-definitive and definitive plumages, and individual-specific field marks included variation of feathers molted among the flight feathers (primaries, secondaries, and rectrices), distinctive patterns of broken (usually older feathers) and worn flight feathers (see age class assignment for further details), and color variation of the breast, belly, upper and under wing coverts, upper and under tail coverts, and tail. The combination of individual-specific molt patterns and color traits allowed reliable identification of individuals within each austral winter; however, individuals could not be tracked across winters because these traits were not retained between seasons. Although a low probability of misidentification (i.e., double-counting of individuals) within a single austral winter cannot be entirely excluded, the use of multiple independent individual-specific traits substantially minimized this risk. Photographs of each individual were labeled and stored in individual folders and sorted by age class.

Age class assignment

The Black-chested Buzzard-Eagle reaches its Definitive Basic Plumage after undergoing four annual molt cycles in almost 5 years (Seipke 2007; Juhant et al. 2022). Individuals were assigned to age classes primarily based on the molt patterns of flight feathers (especially primaries) and secondarily on the overall coloration patterns of the underparts. Following the nomenclature established by Howell et al. (2003) for species exhibiting delayed plumage maturation, individuals of Black-chested Buzzard-Eagle can be assigned to one of five age classes: Basic I individuals (first winter) show a single generation of primary feathers and no molt waves. Basic II individuals (second winter) show two generations of primaries and one molt wave. Basic III individuals (third winter) show three generations and two molt waves. Basic IV individuals (fourth winter) show two generations and three molt waves. Finally, Basic V individuals (≥fifth winter) have acquired the Definitive Basic (adult) Plumage and replaced all primaries at least once; at this point, it is no longer possible to precisely age individuals by assessing their molt in the flight feathers. See Seipke (2007) and Juhant et al. (2022) for further details on age class assignment.

Physical lesions assessment

To quantify the type and prevalence of lesions, we conducted a systematic analysis of high-resolution, multi-angle photographs obtained during field surveys at both sites. Subsequently, the presence of lesions was categorized into seven broad types: (1) missing legs, digits, or talons included any part of the hindlimb lost through amputation; (2) fractured tarsometatarsus or fractured/luxated digits referred to any complete or partial break of the bones distal to the tibiotarsus, whether closed (skin intact) or exposed (bones protruding), with luxation indicating dislocation of any digit joint; (3) swollen tarsometatarsus-digits joints or digits encompassed any evident enlargement or swelling of the joints or digits, including pododermatitis; (4) hyperkeratosis of legs and digits described any section of skin covering the observable leg segment with increased thickness; (5) wing

fractures included any visible breakage of wing bones; (6) beak and claw overgrowth referred to excessive elongation of the rhinotheca or claws; finally, (7) ocular lesions encompassed any abnormality in the ocular globe, orbit, or eyelids. Lesions were not assigned to a specific body side because photographic coverage and image quality were often unequal between the left and right sides, preventing consistent lateral identification; therefore, we conservatively recorded lesions without distinguishing side.

Data analysis

To compare the minimum number of individuals counted and age-class-specific numbers within and between sites, we summed the number of uniquely identified individuals across two austral winters at each site (i.e., combined winter counts). We used combined winter counts to estimate the minimum apparent number of individuals at each site rather than seasonal averages, given the limited sample size (two winters per site), as this approach provides a more complete and interpretable basis for comparing the number of individuals and lesion prevalence among sites. We recognize that this method yields an estimate of minimum apparent numbers rather than true population size, and results should be interpreted with this limitation in mind.

We expressed lesion prevalence at each study site as a percentage. To estimate overall lesion prevalence per site, individuals exhibiting multiple lesions—whether of the same or different types—were counted only once, as prevalence reflects the proportion of affected individuals rather than the total number of lesions. In contrast, when estimating prevalence by lesion type, individuals exhibiting more than one lesion type were recorded once for each relevant lesion category, because lesion-type prevalence represents the proportion of individuals affected by each specific lesion.

We assessed age structure of counted individuals at each site using Chi-square goodness-of-fit tests on combined winter counts, comparing observed age-class frequencies to an expected uniform distribution representing equal representation across age classes. We then used Chi-square tests of independence to evaluate: (1) differences in age structure between the northern site (surveyed in 2022 and 2023) and the southern site (surveyed in 2014 and 2016), (2) the association between age class and lesion count, and (3) the association between age class and the most common lesion type (swollen tarsometatarsus-digits joint or digits), as this lesion provided adequate sample sizes across all age classes at both sites, whereas other lesion types were insufficient for statistical analysis. For significant results ($P < 0.05$), we conducted post hoc analyses of standardized residuals to identify which age classes deviated from expected frequencies (Agresti 2018). All analyses were performed in GraphPad Prism version 6.01 (GraphPad Software, San Diego, CA, USA).

Results

Number of individuals and age structure (combined winter counts)

We conducted 209 h of observations over four austral winters (2014, 2016, 2022, and 2023) at two anthropogenic food-rich sites, surveying two winters per site. At the northern site (surveyed in 2022 and 2023), field effort totaled 92 h (46 ± 1.4 h per winter, 1.5 km^2), and at the southern site (surveyed in 2014 and 2016), survey effort totaled 117 h (58 ± 2.1 h per

winter, 1.0 km^2). Across both sites, we recorded 394 Black-chested Buzzard-Eagles, with 203 individuals (52%) at the northern site and 191 (48%) at the southern site (Table 1, Fig. 3A). Counts at the northern site varied nearly 2-fold among winters, whereas southern site counts remained relatively stable, indicating greater interannual variability in detection of individuals overwintering at the northern site (Table 1).

The age structure of detected individuals differed significantly over time and between sites, with the northern site showing a slight skew toward younger age classes ($\chi^2 = 16.29$, df = 4, $P < 0.01$; Fig. 3B), whereas the southern site exhibited a much stronger deviation skewed toward the oldest age class ($\chi^2 = 187.25$, df = 4, $P < 0.0001$; Fig. 3C). Additionally, age structure also differed significantly between sites and time periods ($\chi^2 = 101.01$, df = 4, $P < 0.0001$) (Fig. 3B,C).

Physical lesions

Of the 394 Black-chested Buzzard-Eagles we photographed, 22% (86 individuals) exhibited at least one type of lesion (Fig. 4). Lesion prevalence differed between sites, with 13% (16 of 203) of individuals affected at the northern site and 31% (60 of 191) at the southern site (Fig. 3D). Prevalence of lesions varied across age classes at the southern site ($\chi^2 = 11.74$, df = 4, $P < 0.05$; Fig. 3F) but not at the northern site ($\chi^2 = 2.84$, df = 4, $P \geq 0.5$; Fig. 3E). Post-hoc analysis at the southern site revealed that individuals in Basic V plumage had a significantly higher prevalence of lesions than expected, whereas those in Basic I and IV plumages showed significantly lower prevalence. Individuals in Basic II and III plumages showed no significant deviation from expected prevalence.

We identified a total of 102 lesions in 86 individuals at both sites, yielding a ratio of 1.19 lesions per individual (Table 1, Fig. 4 for lesion examples). Of all lesions identified, 72%

Table 1. Raw data on the number of individuals, individuals with physical lesions, and number of physical lesions (i.e., some individuals exhibited more than one lesion category) in Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*) overwintering at two anthropogenic food-rich sites in Argentine Patagonia.

	Northern Site		Southern site		
Age classes	2022	2023	2014	2016	Total
Number of individuals					
Basic I (first winter)	40	5	10	8	63
Basic II (second winter)	41	16	2	8	67
Basic III (third winter)	20	26	28	7	81
Basic IV (fourth winter)	14	14	14	2	44
Basic V (≥fifth winter)	18	9	47	65	139
Total	**133**	**70**	**101**	**90**	**394**
Individuals with physical lesions					
Basic I (first winter)	5	0	1	1	7
Basic II (second winter)	5	1	0	4	10
Basic III (third winter)	2	3	5	3	13
Basic IV (fourth winter)	2	2	1	1	6
Basic V (≥fifth winter)	4	2	7	37	50
Total	**18**	**8**	**14**	**46**	**86**
Number of physical lesions					
Basic I (first winter)	5	0	1	1	7
Basic II (second winter)	6	1	0	4	11
Basic III (third winter)	2	4	9	4	19
Basic IV (fourth winter)	2	2	1	1	6
Basic V (≥fifth winter)	4	2	8	45	59
Total	**19**	**9**	**19**	**55**	**102**

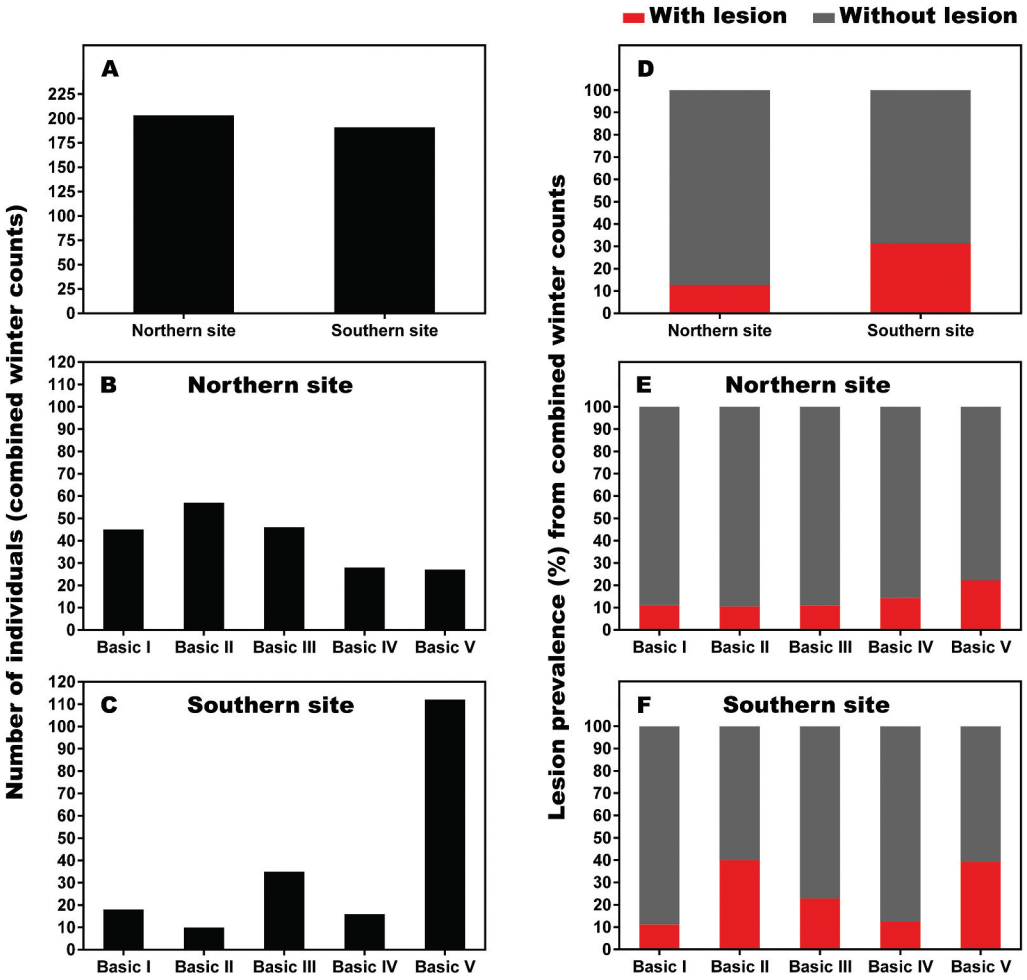


Figure 3. Number of individuals (combined winter counts; 2022–2023 for the northern site and 2014/2016 for the southern site) of Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*) overwintering at two anthropogenic food-rich sites in Argentine Patagonia. (A) Number of individuals (all age classes combined) by site. (B and C) Number of individuals by age class. (D) Prevalence of physical lesions (all age classes combined). (E and F) Prevalence of physical lesions by age class.

corresponded to swollen tarsometatarsus-digits joint or digits, 14% involved missing legs, digits, or talons, three lesion types each accounted for 4%—fractured tarsometatarsus or fractured/luxated digits, wing fractures, and beak and claw overgrowth—and two lesion types each represented 1%—hyperkeratosis of legs and digits, and ocular lesions. The most prevalent lesion type at both sites was swollen tarsometatarsus-digits joint or digits (Fig. 5A). We recorded five lesion types at each site, as wing fractures and ocular lesions were found exclusively at the northern site, while hyperkeratosis of the legs and digits, along with beak and claw overgrowth, were observed only at the southern site (Fig. 5A).

We observed distinct patterns in the prevalence of swollen tarsometatarsus-digits joint or digits at both the site/year and age class levels (Fig. 5B). At the northern site, no significant differences in the prevalence of this lesion were observed across age classes ($\chi^2 = 1.25$, df = 4,

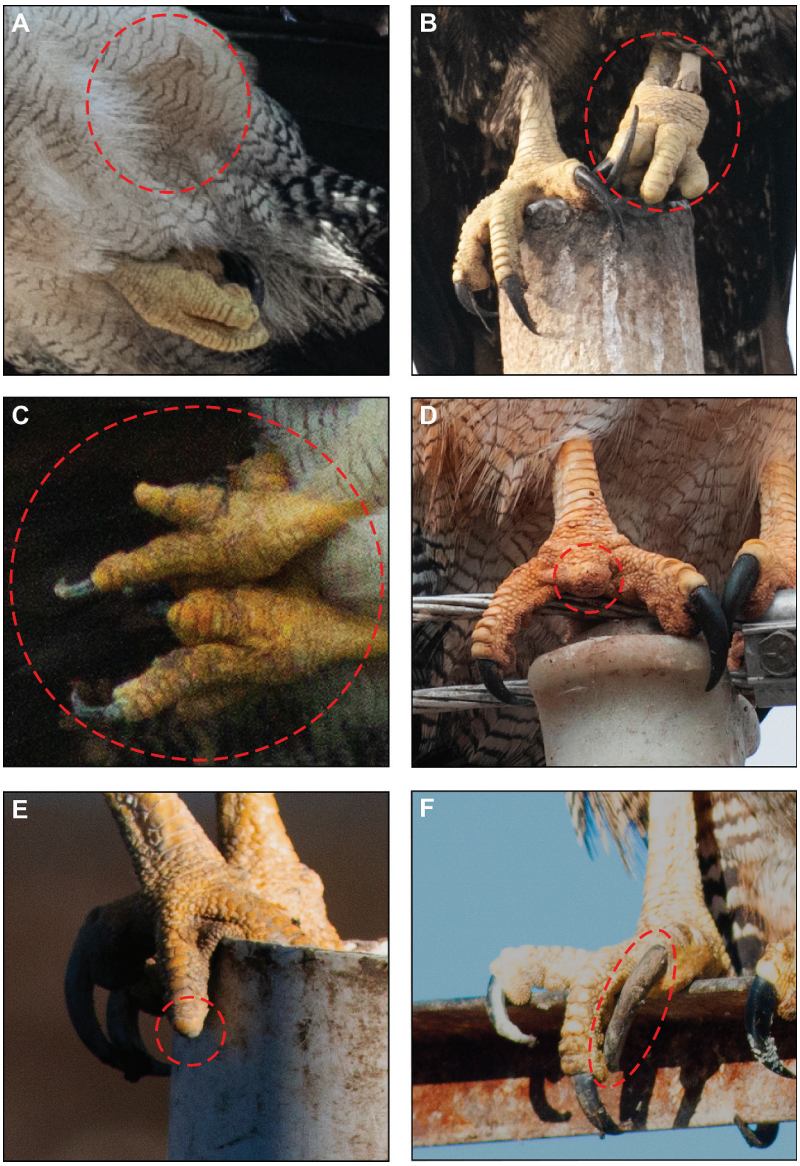


Figure 4. Hindlimb lesions in Black-chested Buzzard-Eagles (*Geranoaetus melanoleucus*) overwintering at two anthropogenic food-rich sites in Argentine Patagonia ranged in severity, from most to least severe. (A) Basic V (≥fifth winter) with an amputated leg (northern site). (B) Basic II (second winter) with the tarsometatarsus including the distal joint with exposed, devitalized, and distal fragment with swelling of digits and the tarsometatarsus-phalangeal joint and fibrosis that entraps tendons deforming and contracting talons (northern site) (panel adapted from Juhant et al. 2024). (C) Basic V (≥fifth winter) with severe bilateral swelling of the tarsometatarsus-phalangeal joints and digits (southern site). (D) Basic IV (fourth winter) with amputated middle or third toe (northern site). (E) Basic V (≥fifth winter) with partially amputated fourth toe (southern site). (F) Basic III (third winter) with overgrown claw in the second toe (southern site). Photos by Matías A. Juhant.

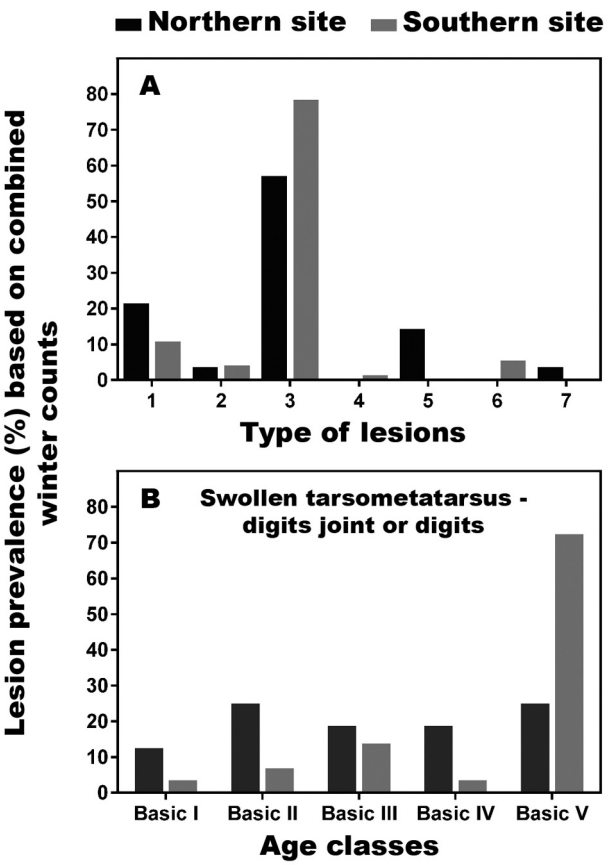


Figure 5. Prevalence of physical lesion types in Black-chested Buzzard-Eagle (*Geranoaetus melanoleucus*) overwintering at two anthropogenic food-rich sites in Argentine Patagonia: (A) distribution of the seven physical lesion types by site. The X-axis represents the physical lesion types: 1 (missing legs, digits, or talons); 2 (fractured tarsometatarsus, fractured/luxated digits); 3 (swollen tarsometatarsus-digits joint or digits); 4 (hyperkeratosis of legs and digits); 5 (wing fracture); 6 (beak and talon overgrowth); 7 (ocular lesion). (B) prevalence of the most common physical lesion type, swollen tarsometatarsus-digit joint or digits, by age class and site.

$P \geq 0.5$), with a relatively even distribution across the age classes (Fig. 5B). In contrast, at the southern site, significant differences in the prevalence of this lesion were found across age classes ($\chi^2 = 108.21$, df = 4, $P < 0.001$), with a strongly left-skewed distribution (Fig. 5B). Post-hoc analysis revealed that Basic V exhibited a significantly higher frequency of lesions than expected, while Basic I and IV showed significantly lower frequencies. Basic II and III did not significantly deviate from expected frequencies.

Discussion

To the best of our knowledge, this is the first study to analyze the number of individuals and age structure alongside the prevalence of age-specific lesion types in Black-chested Buzzard-Eagles overwintering at anthropogenic food-rich sites of Patagonia. Our results show that

large numbers of individuals congregate at these sites each austral winter, with a substantial proportion exhibiting a high prevalence of lesions and a wide range of lesion types. The repeated occurrence and severity of lesions within localized areas across multiple individuals and sites could suggest an anthropogenic origin, although alternative causes cannot be entirely ruled out without detailed investigation.

Number of individuals and age structure (combined winter counts)

The two anthropogenic food-rich sites we surveyed sustain high numbers of overwintering Black-chested Buzzard-Eagles. Such congregations are comparable to those observed during rare, irregular winter irruptions in natural congregation areas at milder latitudes—such as the Monte Desert and Espinal of central Argentina (López et al. 2017; Juhant et al. 2022, Juhant unpublished data)—where more than 100 individuals have been documented in a single austral winter. Although the drivers of natural congregations remain uncertain, they are often associated with temporary increases in prey availability (López et al. 2017; Juhant et al. 2022). In contrast, the high concentrations observed at these two sites are most plausibly explained by easy access to anthropogenic food.

We observed contrasting age-structure patterns between the two sites surveyed at different times: younger age classes (Basic I—III) predominated at the northern site that was surveyed in 2022 and 2023, whereas the oldest age class (Basic V) dominated at the southern site that was surveyed in 2014 and 2016. Although surveys were conducted nearly a decade apart, statistical analyses indicate that these differences persist despite interannual variation at the northern site. Because our data do not allow us to disentangle temporal and spatial effects, we suspect that the northern site attracts individuals from a broader range of age classes and latitudinal origins—consistent with south-to-north movements during the austral autumn—whereas the southern site appears to be occupied primarily by resident individuals. This prediction could be tested by determining whether older individuals cease migratory movements upon reaching Definitive Basic Plumage, as reported for some raptors in the boreal temperate region (Bloom et al. 2015; Panuccio et al. 2021). Notably, no reverse migration—from north to south—has been documented during the austral autumn for either Black-chested Buzzard-Eagles or other raptor species wintering in southern South America (Juhant 2022), which further supports this interpretation. Nevertheless, additional data demonstrating population stability over the course of our study period would be important for fully interpreting these patterns.

Physical lesions

Long-term monitoring at two natural congregation areas in the Argentine Andes—spanning 10 and 14 austral winters—revealed remarkably few lesions among more than 2,000 Black-chested Buzzard-Eagles and Variable Hawks (*Geranoaetus polyosoma*) (Juhant et al. 2022; Juhant 2026, Juhant unpublished data). In contrast, short-term monitoring over four austral winters at two anthropogenic food-rich sites revealed markedly higher lesion prevalence and severity (e.g., Fig. 3A,B), with 22% of Black-chested Buzzard-Eagles affected overall. For context, studies in North America report 18% of individuals with tarsometatarsus injuries from electric shock, 9% with broken or missing talons, bumblefoot, healed wing fractures, or ocular damage, and only 2% with ocular lesions or abnormalities (Dwyer

2006; Bedrosian and St. Pierre 2007; Holt and Layne 2008). These comparisons suggest that lesion prevalence in these two anthropogenic food-rich sites in Patagonia is comparable to or higher than previously documented in other raptor populations.

Hindlimb lesions (e.g., missing legs, digits, or talons, and swollen tarsometatarsus-digit joints) were the most prevalent type observed in Black-chested Buzzard-Eagles. Similar lesions have previously been documented in this species and other scavenging raptors in Patagonia (De Lucca and Saggese 1989; Hiraldo et al. 1995; Juhant et al. 2024). Three non-exclusive processes may explain the high prevalence of hindlimb lesions at these sites. First, food-rich and predictable resources may attract handicapped individuals already carrying lesions that benefit from easy-to-access food sources, leading to their overrepresentation. Second, lesions may be acquired locally, as a result of trauma (entanglement, cuts, and abrasions) and unsanitary foraging conditions (e.g., carcass waste piles and discarded meat mixed with garbage) may promote infection of existing wounds (Cooper 2007). Finally, traumatic injuries could result from leg-hold traps—a common practice among ranchers across Patagonia aimed at killing carnivores and secondarily affecting scavenging raptors (Díaz et al. 2020; Juhant et al. 2024)—and/or from non-fatal electrocution, a threat documented in central Argentina (Ibarra and De Lucca 2015; Gallego-García et al. 2026) but poorly documented in Patagonia, with available records restricted to the northern region (Gallego-García et al. 2026), without implying its absence elsewhere. Taken together, such severe and recurrent hindlimb lesions likely reduce individual mobility and foraging efficiency, potentially limiting survival and recruitment, thereby posing broader implications for population viability of Black-chested Buzzard-Eagles overwintering at anthropogenic sites.

Hindlimb lesions were observed across all age classes of Black-chested Buzzard-Eagles, from the youngest (Basic I) to the oldest (Basic V), indicating that fledglings may become vulnerable soon after gaining independence. The disproportionately high prevalence of lesions in Basic V individuals at the southern site likely reflects cumulative exposure over time rather than an intrinsic vulnerability of this age class. This pattern appears to result from a combination of ecological and demographic factors. Consequently, lesions observed in these older individuals could have been acquired earlier in life across a wide geographic and temporal range, at the southern site itself, or through a combination of both. Demographically, although lesions occur across all age classes, the underrepresentation of younger individuals at the southern site may exaggerate the apparent age-specific pattern. Taken together, these observations suggest that the higher prevalence of lesions in older individuals primarily reflects population structure and life-history dynamics, including the ontogeny of the annual cycle, rather than age-specific susceptibility.

Other less common lesions—such as hyperkeratosis, beak and talon overgrowth, and ocular abnormalities–may result from non-traumatic causes including nutritional deficiencies, infections, or systemic diseases (Cooper 2007; Samour 2016; Scott 2020). Beak and talon deformities have been associated with avian keratin disorder, while ocular lesions may stem from trauma, parasites, or viral infections such as West Nile virus or avian poxvirus (Cooper 2007; Samour 2016; Scott 2020). These conditions could be exacerbated at anthropogenic food-rich sites, where poor diet quality, unsanitary conditions, and chronic stress may contribute to multifactorial or progressive lesions.

Beyond the diversity of lesion types and potential etiologies, their temporal dynamics also warrant consideration. We detected pronounced inter-annual variation in the number of individuals exhibiting lesions at both sites. These values

reflect general inter-annual patterns at each site, as individuals could not be identified across years. Such contrasting patterns suggest that lesion prevalence is shaped by a complex and currently unresolved set of interacting factors, as it may reflect both the local prevalent causes, the acquisition of lesions and the attraction to these places of already affected individuals; therefore, interpretations should be made cautiously in the absence of established causal links.

Conclusion and further recommendations

Overall, our findings demonstrate that lesions are widespread among Black-chested Buzzard-Eagles at two anthropogenic food-rich sites separated by 1,750 km in Argentine Patagonia, affecting nearly one in five individuals across all age classes and highlighting important considerations for conservation. Future research integrating direct physical examinations, necropsies, and telemetry tracking will be essential to elucidate the causes of lesions and quantify their impacts on fitness and survival. We also advocate for a systematic mapping of anthropogenic food-rich sites across Patagonia where scavenger raptors congregate. Together, these efforts will provide critical information for wildlife managers and policymakers seeking to safeguard the health, survival, and long-term viability of scavenging raptor populations in southern South America.

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Author contributions

CRediT: **Matías A. Juhant:** Conceptualization, Data curation, Formal analysis, Funding acquisition, Methodology, Writing – original draft, Writing – review & editing; **Miguel D. Saggese:** Conceptualization, Data curation, Methodology, Writing – original draft, Writing – review & editing.

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ORCID

Matías A. Juhant http://orcid.org/0000-0002-9612-9778

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