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Incidence and outcomes of fractures in birds of prey admitted to three wildlife rehabilitation centers in southern Brazil (2018–2024)

Incidência e desfechos de fraturas em aves de rapina admitidas em três centros de reabilitação de fauna no sul do Brasil (2018–2024)

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Highlights

43.8% of trauma-admitted raptors presented fractures.
Strigiformes were the most affected order in all centers.
Adults accounted for 63.4% of fracture cases.
Thoracic limbs, especially the humerus, were most affected.
Most birds died or were euthanized after suffering fractures.

Abstract

Birds of prey play a crucial role in ecosystems as apex predators, making their conservation essential for environmental balance. However, they face numerous threats, with trauma being the leading cause of admission to rehabilitation centers. This study aimed to characterize fracture cases in birds of prey admitted to three wildlife rehabilitation centers in southern Brazil, describing their occurrence and distribution according to age, season, fracture type, anatomical location, and clinical outcome. Data

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from three centers in Rio Grande do Sul, Brazil, were compiled from 2018 to 2024, including species, age, season, reason for admission, and outcome. A total of 605 birds admitted due to trauma were evaluated, of which 265 (43.8%) presented one or more fractures. The proportion of fractures was 51.7% at Núcleo de Reabilitação da Fauna Silvestre (NU), 50.9% at Zoológico Municipal de Canoas (ZC), and 37.2% at Clínica Veterinária Toca dos Bichos (TB). Strigiformes was the most affected order across all institutions. Adults accounted for most cases (63.4%), followed by juveniles (24.9%) and chicks (6.0%). Open fractures, often associated with poor prognosis, represented 45.1% at NU, 12.5% at ZC, and 14.8% at TB. Thoracic limbs were most frequently affected, especially the humerus. The summer season had the highest number of admissions (30.1%). Overall, 196 of 265 birds (74.0%) died or were euthanized, with higher frequency in cases involving open fractures. These findings highlight the need for improved fracture documentation and emphasize preventive measures to reduce trauma-related injuries, contributing to better management and rehabilitation strategies for birds of prey.
Key words: Humerus. Raptors. Thoracic limb. Trauma. Wildlife rehabilitation.

Resumo

As aves de rapina desempenham um papel crucial nos ecossistemas como predadores de topo, tornando sua conservação essencial para o equilíbrio ambiental. No entanto, enfrentam inúmeras ameaças, sendo o trauma a principal causa de admissão em centros de reabilitação. Este estudo teve como objetivo caracterizar os casos de fraturas em aves de rapina admitidas em três centros de reabilitação de fauna no sul do Brasil, descrevendo sua ocorrência e distribuição de acordo com idade, estação do ano, tipo de fratura, localização anatômica e desfechos clínicos. Dados de três centros no Rio Grande do Sul, Brasil, foram compilados de 2018 a 2024, incluindo espécie, idade, estação do ano, motivo da admissão e desfecho. Um total de 605 aves admitidas por trauma foi avaliado, das quais 265 (43,8%) apresentaram uma ou mais fraturas. A proporção de fraturas foi de 51,7% no Núcleo de Reabilitação da Fauna Silvestre (NU), 50,9% no Zoológico Municipal de Canoas (ZC) e 37,2% na Clínica Veterinária Toca dos Bichos (TB). Sendo, o úmero o osso mais afetado nos membros torácicos (32,84%), o fêmur nos membros pélvicos (27,54%) e o bico no segmento cabeça-tronco com 36,36%. A ordem Strigiformes foi a mais afetada em todas as instituições. Adultos representaram a maioria dos casos (63,4%), seguidos por juvenis (24,9%) e filhotes (6,0%). Fraturas abertas, frequentemente associadas a pior prognóstico, representaram 45,1% no NU, 12,5% no ZC e 14,8% no TB. Os membros torácicos foram os mais frequentemente acometidos, especialmente o úmero. A estação do verão apresentou o maior número de admissões (30,1%). No geral, 196 das 265 aves (74,0%) morreram ou foram eutanasiadas, com maior frequência em casos envolvendo fraturas abertas. Esses achados destacam a necessidade de melhor documentação das fraturas e enfatizam medidas preventivas para reduzir lesões relacionadas a trauma, contribuindo para melhores estratégias de manejo e reabilitação de aves de rapina.
Palavras-chave: Membro torácico. Rapinantes. Reabilitação de fauna silvestre. Trauma. Úmero.

Introduction

Birds of prey represent a group of predatory birds that are vital to the environments they inhabit, as they act as apex predators in the food chain, meaning their conservation is directly linked to environmental conservation. Nevertheless, these animals face a number of threats (Instituto Chico Mendes de Conservação da Biodiversidade [ICMBio], 2008). Trauma is the most common reason for the admission of birds of prey for rehabilitation worldwide (Komnenou et al., 2005; Kelly & Band, 2006; Montesdeoca et al., 2016; Morel et al., 2025). These traumas are primarily caused by direct human actions, such as hunting with firearms, or indirect actions, such as collisions with vehicles, buildings, fences, and power lines (Molina-López et al., 2011).

Fractures are often associated with trauma (Fix & Barrows, 1990; Wendell et al., 2002; Molina-López et al., 2011). Few studies specify the anatomical location of the fractures, such as a study in Greece where the highest incidence was in the wing (humerus, radius, ulna, carpus and metacarpals) (Komnenou et al., 2005), as well as two studies conducted in Brazil (Prusch et al., 2022; Schüler, 2022). The aim of this study was to characterize fracture cases in birds of prey admitted to three wildlife rehabilitation centers in southern Brazil, describing their occurrence and distribution according to age, season, fracture type, anatomical location, and clinical outcomes.

Material and Methods

A survey of the entry registration forms and/or clinical records of birds of prey (Accipitriformes, Falconiformes, Strigiformes, and Cathartiformes) from 1 January 2018 to 31 December 2024 was conducted at three rehabilitation centers: Núcleo de Reabilitação da Fauna Silvestre (NU) in Pelotas, Rio Grande do Sul (RS), Brazil (31°48′03″S 52°24′30″W); Clínica Veterinária Toca dos Bichos (TB) in Porto Alegre, RS, Brazil (30°00′49″S 51°10′42″W); and Zoológico Municipal de Canoas (ZC) in Canoas, RS, Brazil (29°55′00″S 51°10′07″W). The data were compiled in Microsoft Excel software, with three tables created, one for each center. These tables contained the each animal's species, age (chick = birds with down feathers and usually less than 60 days old, juvenile = with juvenile plumage, and adult = fully grown, definitive plumage, after second year) (Figure 1), season (spring = September 23 to December 21, summer = December 22 to March 19, fall = March 20 to June 20, and winter = June 21 to September 22), reason for admission, and outcome.

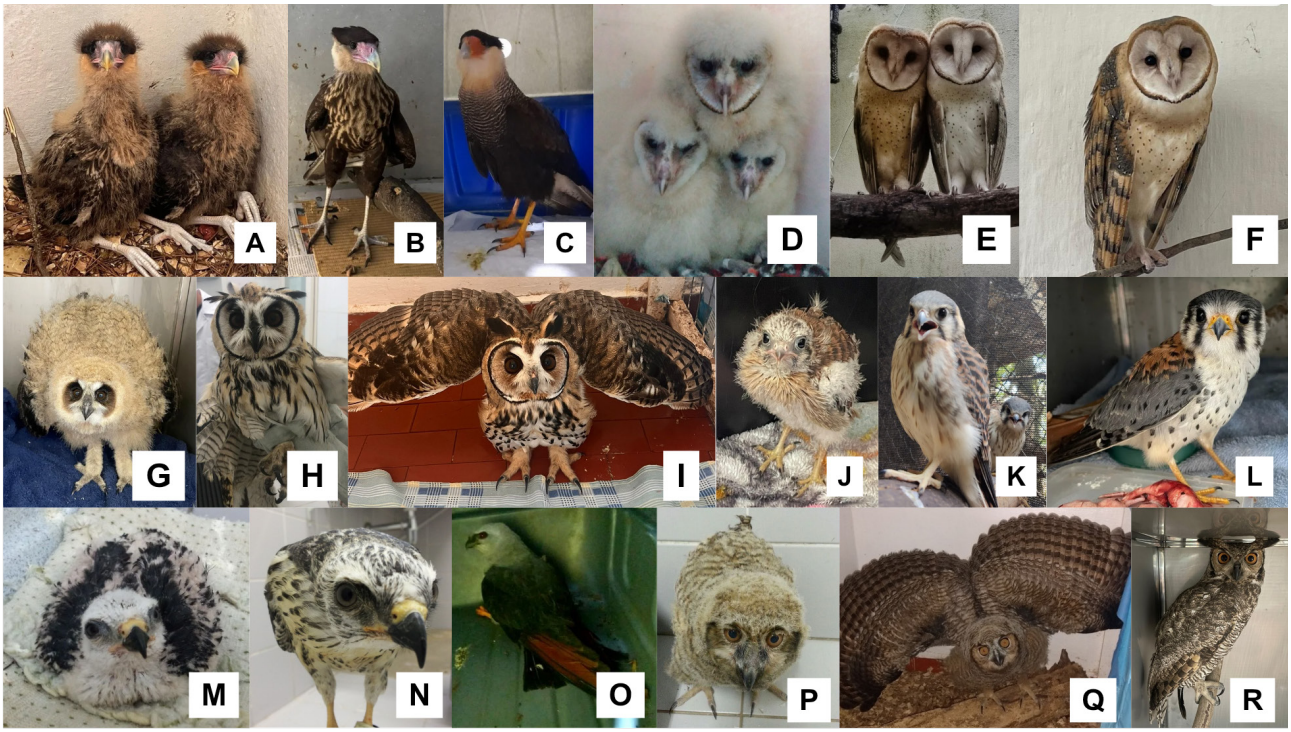

Figure 1. Representative age classes of six birds of prey. A–C: plumbeous kite, *Ictinia plumbea* (chick, juvenile, adult); D–F: southern crested caracara, *Caracara plancus* (chick, juvenile, adult); G–I: American barn owl, *Tyto furcata* (chick, juvenile, adult); J–L: striped owl, *Asio clamator* (chick, juvenile, adult); M–O: American kestrel, *Falco sparverius* (chick, juvenile, adult); P–R: great horned owl, *Bubo virginianus* (chick, juvenile, adult).

From all the raptor records with trauma, only those with bone fractures (detected on clinical examination and/or radiographic findings) were considered, while cases with other non-bone injuries were excluded. Fractures were classified as open or closed based on the information available in the medical records. Cases in which the fracture type was not described were excluded (15 cases).

This study was approved by the Bioethics and Biosecurity Committee of the Federal University of Pelotas (CONCEA-UFPEL; protocol no. 23110.014978/2022-21) and authorized by the Brazilian Biodiversity Information and Authorization System (SISBIO-ICMBio; permit no. 82444-3).

Statistical analysis

Data were analyzed using descriptive and inferential statistics. Absolute and relative frequencies were calculated to characterize the distribution of fracture cases among the rehabilitation centers, taxonomic order, age group, season, affected bone, number of fractures, and clinical outcome. When applicable, proportions were calculated based on the total number of animals within each category.

Associations between age group and clinical outcome and between number of fractures and clinical outcome were assessed using contingency tables. Records with missing information required for these analyses were excluded. For inferential analyses, euthanized animals were grouped with those that died. The adequacy of Pearson's chi-square test was initially assessed based on expected cell frequencies. Because a high proportion of cells had expected frequencies below five, Fisher's exact test was used for both associations. All tests were two-sided, and statistical significance was set at $P < 0.05$. The magnitude of the associations was additionally estimated using Cramér's V with corresponding confidence intervals.

Results and Discussion

A total of 605 birds of prey were admitted as trauma victims over the seven-year study period, of which 265 (43.8%) had one or more fractures. At NU, 176 birds were admitted due to trauma, with 91 (51.7%) showing fractures. At ZC, 106 birds were received, of which 54 (50.9%) had fractures. At TB, 323 birds were admitted as trauma cases, and 120 (37.2%) were diagnosed with fractures.

Among the main bones affected by fractures across the three rehabilitation centers (Figure 2), the humerus was the most frequently fractured bone in the thoracic limbs, accounting for 32.8% of wing fractures, followed by the radius and ulna, which represented 21.4% of the cases. Similarly, in the pelvic limbs, the femur was the most frequently affected bone, accounting for 27.5% of the fractures, followed by the tibiotarsus, with 26.1% of fractures. In the head–trunk region, the beak was the most frequently affected structure, accounting for 36.4% (8/22) of the fractures, followed by the coracoid bone (18.2%, 4/22) and the furcula (clavicle) (13.6%, 3/22).

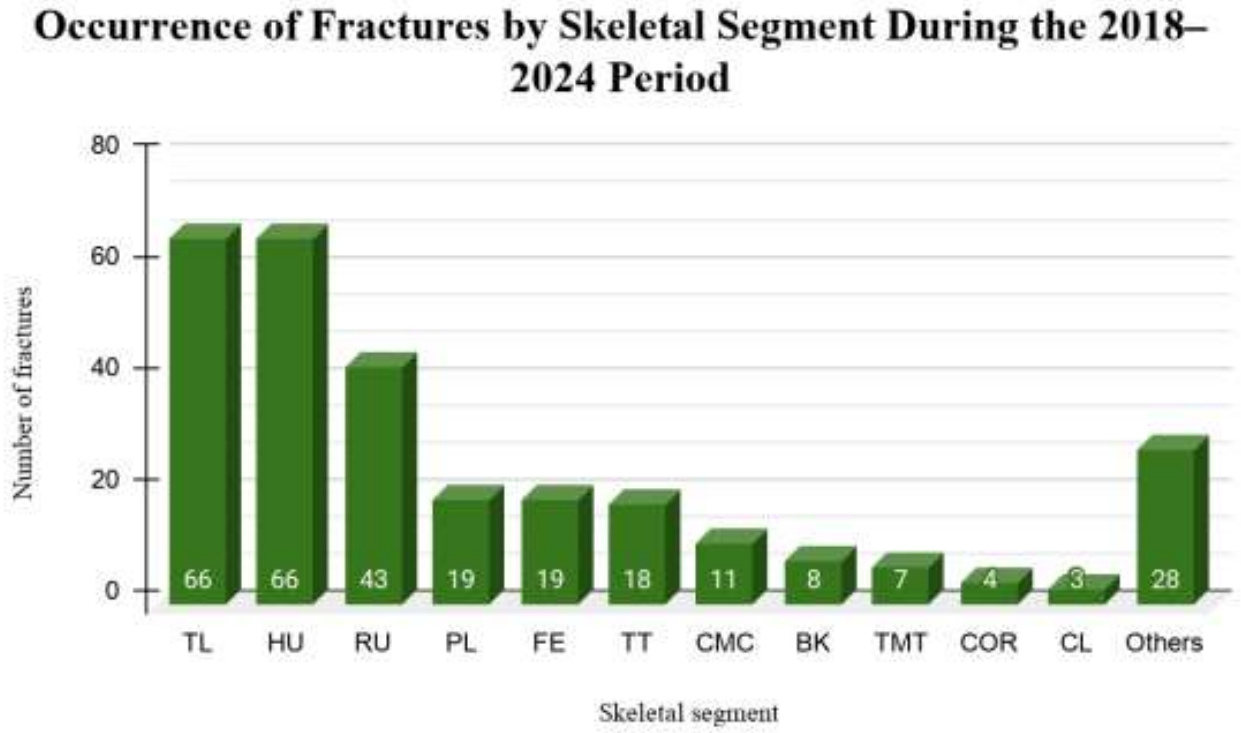

Figure 2. Occurrence of fractures in birds of prey by skeletal segment during 2018–2024. **TL**: thoracic limb; **HU**: humerus; **RU**: radius/ulna; **PL**: pelvic limb; **FE**: femur; **TT**: tibiotarsus; **CMC**: carpometacarpus; **BK**: beak; **TMT**: tarsometatarsus; **COR**: coracoid; **CL**: clavicle; **Others**: ischium, ilium, femorotibiopatellar joint, fibula, pelvic phalanges, scapulohumeral joint, humeroradioulnar joint, radiocarpal joint, metacarpophalangeal joint, thoracic phalanges, mandible, head, vertebral column.

At all rehabilitation centers, birds in the order Strigiformes were the most affected, accounting for 48.4% at NU, 48.1% at ZC, and 45.0% at TB. The other orders showed similar frequency patterns at NU, ZC, and TB: Falconiformes (40.7%, 20.4%, 25.8%, respectively); Accipitriformes (8.8%, 20.4%, 19.2%, respectively); and Cathartiformes (2.2%, 11.1%, 10%, respectively) (Tables 1 and 2). Coutant et al. (2022) reported that species of Strigiformes were among those most frequently affected by humeral fractures in Canada. The predominance of Strigiformes in trauma cases at the rehabilitation centers may be attributed to their susceptibility to anthropogenic trauma. Molina-López et al. (2011) suggested that nocturnal species are more frequently involved in collisions with buildings, vehicles, and fences, likely because of their hunting behavior and their tendency to be startled during flight. Likewise, several studies have identified vehicle collisions as one of the principal causes of trauma in owls (Telfer, 1973; Newton et al., 1991; Aye et al., 1996; Work & Hale, 1996).

Table 1
Incidence by species, local, age, fracture site and outcome of birds of prey (*Strigiformes* & *Falconiformes*) admitted from 2018 to 2024 in three rehabilitation centers in southern Brazil

	Individuals	Local	Age (Chick/Juvenile/ Adult/No data)	Fracture site (CT/TL/PL/P)	Outcome (Release/ Euthanasia/Death/ Captivity/No data)
Strigiformes	124				
Megascops choliba	28	14 (TB)	0/7/6/1	0/12/2/0	0/7/7/0/0
		7 (NU)	0/1/6/0	0/5/1/1	1/4/2/0/0
		7 (ZC)	0/0/5/2	0/5/1/1	2/2/1/1/1
Tyto furcata	24	11 (TB)	3/4/4/0	0/8/3/0	2/6/2/0/1
		8 (NU)	0/2/6/0	0/8/0/0	0/8/0/0/0
		5 (ZC)	1/1/2/1	0/4/1/0	1/0/3/0/1
Asio clamator	23	11 (TB)	1/2/8/0	1/8/1/1	2/5/3/1/0
		6 (ZC)	1/0/5/0	1/4/1/0	0/3/1/0/2
		6 (NU)	0/1/5/0	0/6/0/0	0/6/0/0/0
Athene cunicularia	18	7 (TB)	0/3/3/1	2/4/1/0	2/3/2/0/0
		7 (NU)	0/3/4/0	0/4/3/0	1/6/0/0/0
		4 (ZC)	0/0/3/1	1/3/0/0	0/1/3/0/0
Bubo virginianus	17	13 (NU)	0/1/12/0	1/10/1/1	1/11/1/0/0
		4 (TB)	0/1/3/0	0/4/0/0	2/2/0/0/0
		0 (ZC)	-	-	-
Asio stygius	12	7 (TB)	0/1/4/2	1/5/0/1	1/1/4/0/1
		4 (ZC)	0/0/4/0	0/3/0/1	0/0/3/0/1
		1 (NU)	0/1/0/0	0/1/0/0	0/1/0/0/0
Glaucidium brasilianum	2	2 (NU)	0/1/1/0	1/1/0/0	2/0/0/0/0
		0 (ZC)	-	-	-
		0 (TB)	-	-	-
Falconiformes	79				
Falco sparverius	47	20 (TB)	1/7/11/1	0/16/3/1	3/12/4/0/1
		19 (NU)	0/2/17/0	0/16/2/1	1/13/5/0/0
		8 (ZC)	0/2/5/1	0/6/0/2	2/4/1/0/1
Caracara plancus	20	11 (NU)	0/3/8/0	1/3/6/1	3/8/0/0/0
		8 (TB)	0/1/6/1	0/5/3/0	4/1/3/0/0
		1 (ZC)	0/1/0/0	0/0/1/0	0/0/1/0/0
Milvago chimango	10	7 (NU)	0/1/6/0	0/5/2/0	1/6/0/0/0
		2 (TB)	1/0/1/0	1/0/1/0	0/0/2/0/0
		1 (ZC)	0/1/0/0	0/0/1/0	0/0/0/0/1

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Milvago chimachima	2	1 (ZC)	0/0/0/1	0/1/0/0	0/1/0/0/0
		1 (TB)	0/0/1/0	0/1/0/0	1/0/0/0/0
		0 (NU)	-	-	-
TOTAL	203	203	8/47/136/12	10/148/34/11	32/111/48/2/10

TB: Toca dos Bichos, **NU**: Núcleo de Reabilitação da Fauna Silvestre, **ZC**: Zoológico Municipal de Canoas. **CT**: cranial and trunk, **TL**: thoracic limb, **PL**: pelvic limb, **P**: politrauma (more than one fracture site)

Table 2
Incidence by species, local age, fracture site and outcome of birds of prey (*Accipitriformes* & *Cathartiformes*) admitted from 2018 to 2024 in three rehabilitation centers in southern Brazil

	Individuals	Local	Age (Chick/Juvenile/ Adult/No data)	Fracture site (CT/TL/PL/P)	Outcome (Release/ Euthanasia/Death/ Captivity/No data)
Accipitriformes	42				
Rupornis magnirostris	20	11 (TB)	1/4/6/0	0/7/3/1	4/4/3/0/0
		6 (ZC)	0/1/4/1	2/3/1/0	2/0/2/0/2
		3 (NU)	0/3/0/0	0/0/1/2	1/2/0/0/0
Buteo brachyurus	5	3 (TB)	0/1/2/0	0/3/0/0	0/0/1/1/1
		2 (ZC)	1/0/1/0	0/1/1/0	0/1/1/0/0
		0 (NU)	-	-	-
Heterospizias meridionalis	4	3 (TB)	0/1/2/0	0/1/0/2	1/2/0/0/0
		1 (NU)	0/0/1/0	0/0/1/0	0/0/1/0/0
		0 (ZC)	-	-	-
Ictinia plumbea	4	2 (ZC)	0/1/0/1	0/2/0/0	0/1/0/0/1
		2 (TB)	1/1/0/0	0/2/0/0	1/1/0/0/0
		0 (NU)	-	-	-
Circus buffoni	3	3 (NU)	0/1/2/0	0/3/0/0	0/2/1/0/0
		0 (ZC)	-	-	-
		0 (TB)	-	-	-
Accipiter striatus	3	2 (TB)	0/1/1/0	0/2/0/0	0/0/2/0/0
		1 (ZC)	0/0/1/0	0/1/0/0	0/0/1/0/0
		0 (NU)	-	-	-
Urubitinga urubitinga	1	1 (TB)	0/1/0/0	0/1/0/0	0/0/0/1/0
		0 (ZC)	-	-	-
		0 (NU)	-	-	-

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Rostrhamus sociabilis	1	1 (NU)	0/0/1/0	0/1/0/0	0/1/0/0/0
		0 (ZC)	-	-	-
		0 (TB)	-	-	-
Geranoaetus albicaudatus	1	1 (TB)	0/1/0/0	0/1/0/0	1/0/0/0/0
		0 (NU)	-	-	-
		0 (ZC)	-	-	-
Cathartiformes	20				
Coragyps atratus	19	11 (TB)	4/1/5/1	0/5/6/0	6/3/2/0/0
		6 (ZC)	1/1/4/0	0/3/3/0	2/2/2/0/0
		2 (NU)	0/1/1/0	0/1/1/0	1/0/1/0/0
Cathartes aura	1	1 (TB)	0/0/1/0	0/1/0/0	0/0/1/0/0
		0 (ZC)	-	-	-
		0 (NU)	-	-	-
TOTAL	62	62	8/19/32/3	2/38/17/5	19/19/18/2/4

TB: Toca dos Bichos, **NU**: Núcleo de Reabilitação da Fauna Silvestre, **ZC**: Zoológico Municipal de Canoas. **CT**: cranial and trunk, **TL**: thoracic limb, **PL**: pelvic limb, **P**: politrauma (more than one fracture site).

At all rehabilitation centers, adult birds were the most frequently admitted (63.4%, 168/265) (Table 1). Juveniles represented 24.9%, whereas chicks were only 6.0%. Age could not be determined for 5.6% of the birds; therefore, these birds were not considered in the age-related comparisons but were retained for the analysis of other variables. Adults were the most frequently admitted because this life stage is the most active and are involved in long flights in search of food and resources for reproduction (Newton, 1977; Baumgarten, 1998; Granzinolli et al., 2002). Juveniles were the second most admitted because their inexperience and partial dependence on parents limit their time away from nests, thus reducing their susceptibility to accidents. Nestlings were the least affected by fractures because their habit of remaining in the nest under parental care and being fed by their parents minimizes their exposure to risks (Newton, 1977; Baumgarten, 1998; Granzinolli et al., 2002).

Age group and number of fractures were not significantly associated with clinical outcome (P = 0.139 and P = 0.327, respectively). The magnitude of both associations was small, as indicated by Cramér's V values of 0.141 and 0.111, respectively (Table 3).

Table 3
Association of age group and number of fractures with clinical outcome in birds of prey included in the inferential analysis

Variable / category	Captivity n (%)	Death/ Euthanasia n (%)	Release n (%)	Treatment n (%)	P	Cramér's V
Age - Adult (n=129)	1 (0.8)	106 (82.2)	21 (16.3)	1 (0.8)	0.139	0.141
Age - Chick (n=14)	0 (0.0)	8 (57.1)	5 (35.7)	1 (7.1)		
Age - Juvenile (n=53)	1 (1.9)	40 (75.5)	11 (20.8)	1 (1.9)		
Fractures - 1 (n=156)	2 (1.3)	119 (76.3)	32 (20.5)	3 (1.9)	0.327	0.111
Fractures - 2 (n=38)	0 (0.0)	34 (89.5)	4 (10.5)	0 (0.0)		
Fractures - 3 (n=2)	0 (0.0)	1 (50.0)	1 (50.0)	0 (0.0)		

Note: Percentages are calculated within each age or fracture-number category. Euthanized birds were grouped with those that died for inferential analysis. P values were obtained using two-sided Fisher's exact tests. Cramér's V represents the magnitude of association.

The highest number of admissions (n = 80) across the three rehabilitation centers occurred in summer (Figure 3). In the spring, there were 66 admissions, whereas in winter 63 injured birds of prey were admitted and in autumn 52 birds. For 1.5% of the birds, there was no specified admission date. The reproductive period of most of the species involved in the study occurs between August and November. In some cases, however, it may extend from January to June (Baumgarten, 1998). During the reproductive period, raptors exhibit increased activity due to the need for preparation, construction, or rearrangement of nests (Newton, 1977) and the heightened search for food to meet the energetic demands of adults, who experience significant energy expenditure due to reproduction, as well as the growing and developing offspring (Newton, 1977; Baumgarten, 1998).

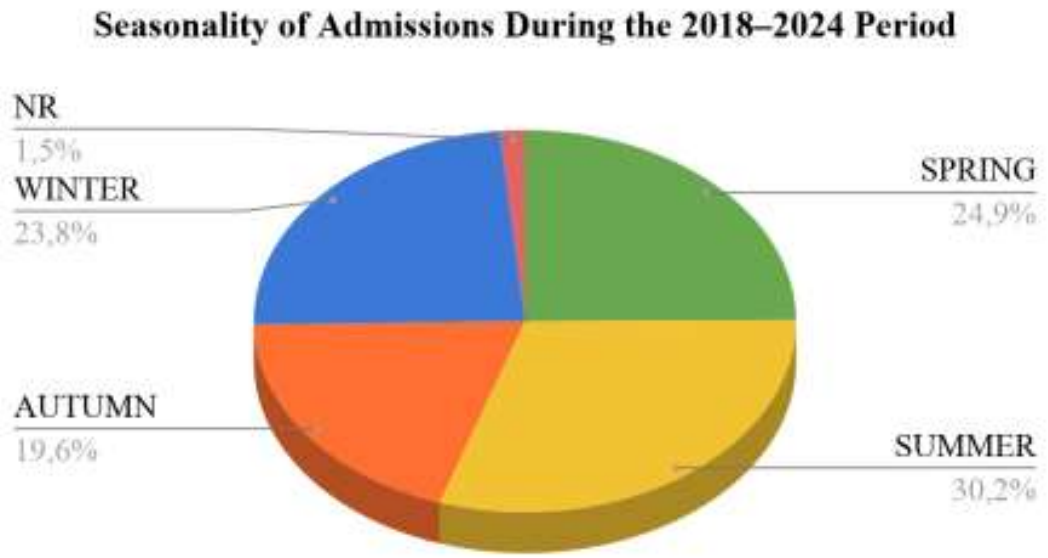

Figure 3. Seasonality of admissions of birds of prey to three rehabilitation centers in southern Brazil during 2018–2024.
NR: Not reported.

In addition to seasonal changes in raptor behavior associated with reproduction, increased human activity during the summer, including recreational activities, tourism, and road traffic, may also contribute to higher admission rates. Human–wildlife interactions are known to vary seasonally, with warmer months generally associated with greater outdoor human activity and increased opportunities for anthropogenic injuries to wildlife. Consequently, collisions with vehicles, trauma, and other human-related causes may become more frequent during summer, particularly for raptors that forage near roads or human-modified environments (Hager, 2009; Gaston et al., 2020; Cardona et al., 2024).

Among the fractures that were classified, open fractures were more frequent at NU (45.1%) compared to ZC (12.5%) and TB (14.8%). A high proportion of cases lacked specification in the clinical records, accounting for 49% at NU, 81.3% at ZC, and 83.6% at TB. Comminuted fractures and polytraumas had low incidence rates across all rehabilitation centers. Open fractures in raptors are critical injuries that often result in death, euthanasia, or the inability to release the bird back into the wild. These fractures expose bone tissue to the environment, heightening the risk of infection, particularly in birds with poorly vascularized bone structures, and usually are associated with extensive damage to the soft tissue around it (Tully et al., 2010; Coutant et al., 2022). The injury's severity, extent of bone damage, and contamination level are key factors determining treatment viability. When infection is likely and recovery is improbable, euthanasia is considered the most humane option to prevent unnecessary suffering (Cubas & Rabelo, 2014).

The thoracic limbs were the most frequently affected in all locations (Figure 2), accounting for 69.6% of all fractures at NU, 62.5% at ZC, and 70.3% at TB (Table 1 and Figure 4). The pelvic limbs ranked second, followed by the head/trunk region. Of the 294 fracture cases at the three rehabilitation centers, 201 involved the thoracic limbs, corroborating data from other studies that confirm the higher prevalence of fractures in wing bones (Komnenou et al., 2005; Kelly & Bland, 2006; Cococcetta et al., 2022; Prusch et al., 2022; Schüler, 2022; Lima et al., 2026).

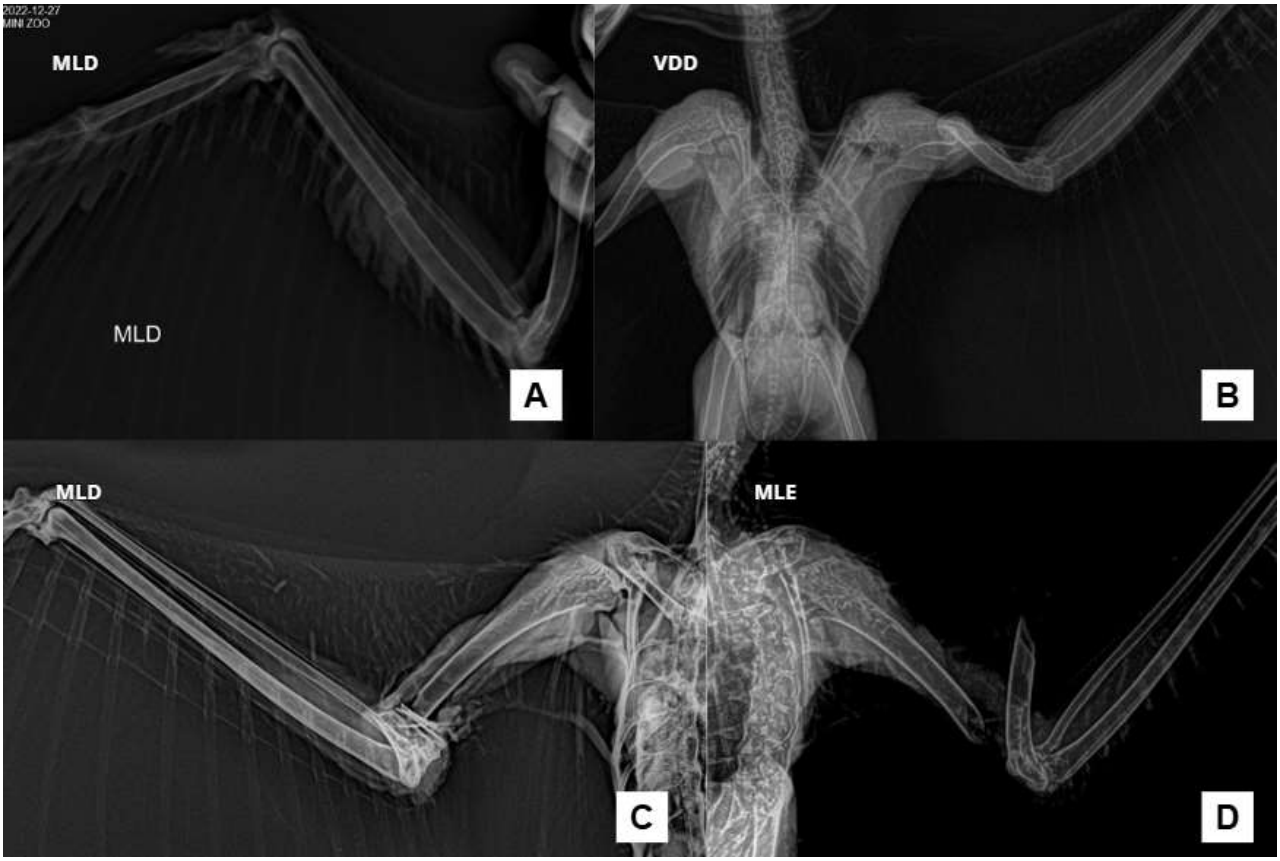

Figure 4. Thoracic limb fractures. (A) Complete mid-diaphyseal fracture of the ulna, mediolateral projection of the right thoracic limb (MLD); (B) Complete proximal diaphyseal fracture of the humerus, ventrodorsal projection of the right thoracic limb (VDD); (C) Complete distal metaphyseal fracture of the humerus, mediolateral projection of the right thoracic limb (MLD); (D) Complete distal diaphyseal fracture of the humerus, mediolateral projection of the left thoracic limb (MLE). Courtesy of Plenavet.

At NU, the humerus was the most affected segment in the thoracic limbs, accounting for 45.1% (32/71 of wing fractures). The radius and ulna was the second most affected (29.6%, 21/71). At ZC, the humerus was also the most affected segment, accounting for 35% (14/40) of wing fractures. At TB, the humerus was also the most frequently affected bone, accounting for 22.2% (20/90) of all fractures, while the radius and ulna was the second most frequently affected segment (13.3%, 12/90). The higher incidence of fractures in the thoracic limbs of wild raptors could be explained by the fact that birds with wing fractures are more easily found, captured, and taken to rehabilitation centers, unlike cases of fractures in the pelvic limbs, where the birds may still be able to fly and escape (Howard & Redig, 1993).

Fracture patterns in the pelvic limbs varied little among the three rehabilitation centers. At NU, the tibiotarsus was the most affected segment (39.1%, 9/23 of pelvic limb fractures), followed by the femur (21.7%, 5/23). At ZC, the femur was the most affected segment (37.5%, 6/16), followed by the tibiotarsus (31.3%, 5/16). At TB, the femur was also the most affected segment (26.7%, 8/30). In 50% (15/30) of pelvic limb fractures, the clinical records did not specify which bone was affected (Figure 5).

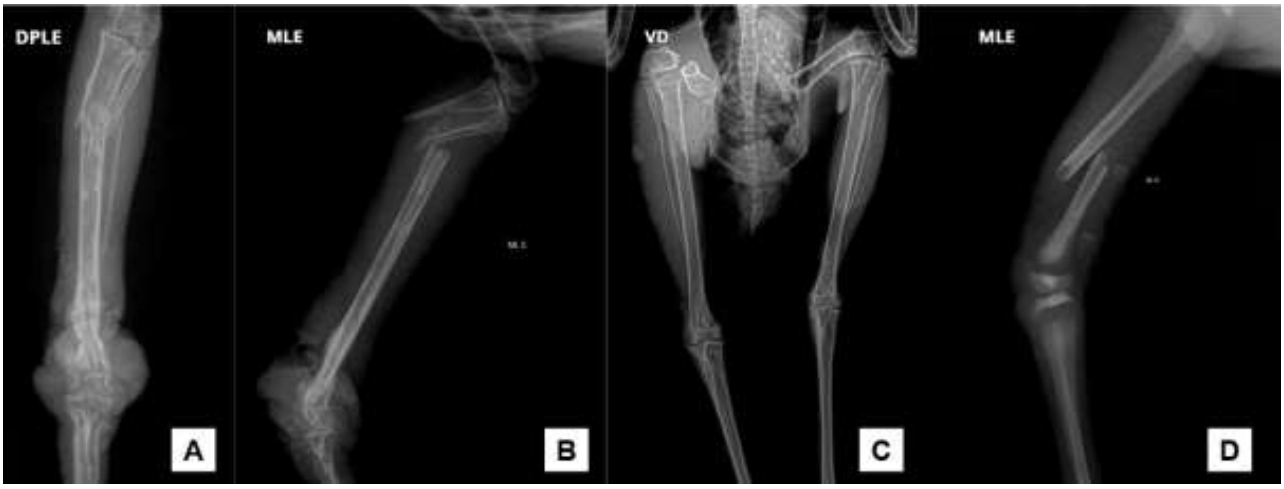

Figure 5. Pelvic limb fractures. (A) Complete proximal diaphyseal fracture of the tibiotarsus, dorsoplantar projection of the left pelvic limb (DPLE); (B) Complete proximal diaphyseal fracture of the tibiotarsus, mediolateral projection of the left pelvic limb (MLE); (C) Complete distal diaphyseal fracture of the femur, ventrodorsal projection (VD); (D) Complete mid-diaphyseal fracture of the tibiotarsus, mediolateral projection of the left pelvic limb (MLE).

Radiography is the complementary diagnostic method of choice in cases of trauma and musculoskeletal disorders, being essential for prognosis and understanding fracture dynamics (Thrall, 2019). Clinical evaluation combined with radiographic images in two planes, typically ventrodorsal (or dorsoventral), with additional mediolateral and craniocaudal projections of the affected wing, allows the prediction of case outcomes, indicating the feasibility of osteosynthesis and the chances of adequate recovery. However, among the 265 bords of prey admitted with fractures to the three rehabilitation centers, we only had access to 21.8% (58/265) of the radiographs. Thus, the selection of individuals undergoing radiographic examination must be based on clinical prognosis, and many animals already with open fractures, severe compromise, and the possibility of humane euthanasia often are not considered priority candidates for the radiographic imaging.

Euthanasia was the most frequent decision for birds with open fractures, reaching 89.1% at NU, 42.9% at ZC, and 68.4% at TB. For unspecified fractures, 39% of birds at the ZC, 38.4% at the TB, and 64% at NU were euthanized. The proportion of released birds was highest at TB (25%) and lower at ZC (18.5%) and NU (13.1%). Even if the bird receives appropriate treatment and the fracture is stabilized, its potential for release may be compromised. Raptors rely on their flight capabilities to hunt and survive, and fractures that impair this ability may confine the bird to a life in captivity (Gonçalves, 2024). Considering these factors, assessing the functional prognosis, i.e., the bird's ability to fly in a flight enclosure and other techniques, becomes essential to making the best decision in favor of the bird's welfare.

Our finding that 74% of the admitted animals with fractures died or were euthanized highlights a critical reality in wildlife veterinary medicine. This high rate of mortality and euthanasia is consistent with outcomes reported by other wildlife rehabilitation centers, where severe orthopedic injuries and trauma are consistently associated with poor release outcomes. For comparison, a retrospective study at a Midwestern United States rehabilitation facility reported an overall release rate of only 39% across common mammal and bird species, with 34% of animals dying naturally and 26% being euthanized (Smith, 2018), a result comparable to the 42% release rate reported by the British Wildlife Rehabilitation Council (Mullineaux, 2014). Although some European centers, such as those in Catalonia, Spain, have reported higher overall release rates of approximately 63% (Molina-López et al., 2017), cases involving fractures and severe trauma consistently present the lowest recovery rates and remain among the greatest diagnostic and therapeutic challenges in wildlife rehabilitation (Smith, 2018).

Discussing these high mortality rates is essential when considering the sustainability of wildlife rehabilitation programs. Because rehabilitation centers care for numerous wildlife species while operating under limited financial and human resources, costly diagnostic and therapeutic interventions in animals with an extremely poor prognosis, such as those with severe or open fractures, may not represent the most effective allocation of resources. Early triage and humane euthanasia therefore serve not

only to minimize animal suffering but also to optimize the use of clinical and financial resources, allowing greater investment in patients with a higher probability of successful rehabilitation and release (Smith, 2018; Sarmiento, 2024).

From a conservation perspective, although wildlife rehabilitation seeks to mitigate the negative impacts of human activities on individual animals, its effectiveness as a direct population management strategy remains debated. Nevertheless, the systematic documentation of admission patterns, clinical outcomes, and causes of mortality provides valuable information for monitoring ecosystem health, identifying anthropogenic threats, detecting disease emergence, and tracking changes in native wildlife populations. Therefore, implementing structured triage protocols that prioritize diagnostic and rehabilitation resources according to clinical prognosis represents an important step toward improving both the economic sustainability of rehabilitation centers and the conservation value of wildlife preservation efforts (Smith, 2018; Sarmiento, 2024).

Our study has some limitations inherent to its retrospective design. Data were obtained from clinical records of different rehabilitation centers, and variations in diagnostic protocols, availability of radiographic examinations, and record completeness may have influenced the classification of fractures. Additionally, each center follows its own rehabilitation, training, and release protocols, which may affect clinical outcomes and release rates. Although these limitations should be considered when interpreting the results, our study provides valuable information regarding fracture occurrence and outcomes in raptors admitted to wildlife rehabilitation centers. Future studies using standardized diagnostic criteria, fracture classification by bone involved, and uniform rehabilitation protocols are warranted to improve comparisons among rehabilitation centers.

Conclusion

Birds in the order Strigiformes were the most affected by fractures. The thoracic limb was the most frequent body part traumatized, with the humerus being the most commonly affected bone. The highest incidence of fracture cases occurred during the summer. Most birds either died or were euthanized as a result of their injuries. Across the three rehabilitation centers, some fracture records lacked specification of the affected bone segment, highlighting the need for improved completion of admission forms.

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