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Fatal traumatic injuries in free-living wild Passeriformes and Psittaciformes birds in Central Brazil, 2006-2018[1]

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ABSTRACT.- Fontoura G.D.R.S., Sousa D.E.R., Macêdo I.L., Hirano L.Q.L. & Castro M.B. 2023. **Fatal traumatic injuries in free-living wild Passeriformes and Psittaciformes birds in Central Brazil, 2006-2018**. *Pesquisa Veterinária Brasileira 43:e07275, 2023.* Laboratório de Patologia Veterinária, Faculdade de Agronomia e Medicina Veterinária, Universidade de Brasília, Via L4 Norte – Asa Norte, Brasília, DF 70636-200, Brazil. E-mail: castromb@unb.br

Traumatic injuries are a significant cause of death for birds worldwide, as they are at an increased risk of collisions and other injuries due to man-made environments. This study examined the frequency and morphological characteristics of fatal traumatic injuries in endemic and migratory Passeriformes and Psittaciformes from the Cerrado Biome, a biodiverse but threatened area in Brazil. Results showed that fatal traumatic injuries were found in 21.8% of birds (285/1305), mainly in spring and summer, during the birds' reproductive period. The yellow-chevroned parakeet (*Brotogeris chiriri*) and Passeriformes from the Thraupidae family were the most affected. Nearly 70% of the fatal injuries observed were to the thoracic, pelvic limbs, and skull, and types of fractures and affected bones were thoroughly evaluated. Blunt traumas were one of the most frequent causes of injuries. Injuries affecting the appendicular skeleton and head represented significant causes of traumatic death for Passeriformes and Psittaciformes. The frequency of these fatal injuries has been increasing in recent years, which may be related to the remarkable environmental changes in the Cerrado Biome and jeopardize the survival of many bird species.

INDEX TERMS: Passerines, psittacines, wild birds, anthropic environments, bone fractures.

RESUMO.- [**Injúrias traumáticas fatais em aves Passeriformes e Psittaciformes no Brasil Central, 2006-2018.**] As lesões traumáticas são uma causa significativa de morte nas aves em todo o mundo, pois apresentam um risco maior de colisões e outras lesões devido aos ambientes degradados e criados pelo homem. Este estudo examinou a frequência e as características morfológicas das lesões traumáticas fatais em Passeriformes e Psittaciformes endêmicos e migratórios do Bioma Cerrado, uma área com rica biodiversidade, mas ameaçada no Brasil. Os resultados demostraram que as lesões traumáticas fatais foram observadas em 21,8% das aves (285/1305), principalmente na primavera e verão, durante a época reprodutiva das aves. O periquito-do-encontro-amarelo (*Brotogeris chiriri*) e Passeriformes da família Thraupidae foram as aves mais frequentemente acometidas. Por volta de 70% das lesões fatais observadas foram nos membros torácicos e pélvicos, e crânio, e os tipos de fraturas e ossos afetados foram minuciosamente avaliados. Os traumas contudentes foram as principais causas das lesões. As injúrias que afetaram o esqueleto apendicular e a cabeça representaram as mais importantes causas de morte traumática para Passeriformes e Psittaciformes. A frequência dessas lesões fatais vem aumentando nos últimos anos, o que pode estar relacionado às mudanças ambientais marcantes no Bioma Cerrado e colocar em risco a sobrevivência de muitas espécies de aves.

TERMOS DE INDEXAÇÃO: Passeriformes, psittaciforme, aves silvestres, ambiente antrópico, fraturas ósseas.

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INTRODUCTION

Brazil is known for its rich biodiversity, including over 1,971 bird species, half endemic (Pacheco et al. 2021). The Cerrado biome, mainly located in Central Brazil, is a particularly important area for bird conservation, as it is considered a global biodiversity hotspot (Mittermeier et al. 2011), which has an incredible richness of bird species (Willis 2004, Manica et al. 2010). The current human-driven land changes, such as agricultural expansion and habitat destruction, have significantly impacted the survival of many bird species in this region. As sentinels of ecosystem health, birds are frequently affected by anthropogenic activities and have been used to detect environmental changes worldwide (Smits & Fernie 2013).

The Distrito Federal and its surrounding areas, home to around 4 million people, have an extensive road network and urbanized regions threatening wild birds. Despite the high biodiversity in the region, there is limited information on the causes of death in birds in Brazil. Indeed, the conservation of bird species requires solid knowledge about the most relevant threats to natural populations. Traumatic injuries are among the most life-threatening injuries for birds and are often a result of displacement within anthropogenic matrices, particularly in urbanized areas (Stenkat et al. 2013, Hager et al. 2017, Garcês et al. 2019). This study aimed to characterize fatal traumatic injuries' frequency and morphological features in free-ranging Psittaciformes and Passeriformes birds in Central Brazil from 2006 to 2018.

MATERIALS AND METHODS

Study local and contextualization. A survey of the necropsy records of traumatic injuries in free-living wild Psittaciformes and Passeriformes birds (2006-2018) was conducted at the "Laboratório de Patologia Veterinária", "Universidade de Brasília" (UnB), Brazil. Most birds were collected by the Environmental Military Police or local population in urban, periurban, and natural areas from the Distrito Federal and surrounding areas. All animals were forwarded to the "Centro de Triagem de Animais Silvestres" of the Distrito Federal (CETAS-DF), "Instituto Brasileiro do Meio Ambiente e Recursos Renováveis" (IBAMA), "Ministério do Meio Ambiente e Mudança do Clima". Birds with traumatic injuries were referred for clinical care at the "Clínica de Animais Silvestres", "Hospital Veterinário de Ensino", UnB.

Epidemiological, clinical, and pathological data. Clinical and pathological data and archived images of necropsies were retrieved and evaluated. All selected cases had traumatic injuries and fatal outcomes or were euthanized due to poor prognoses. Frequencies of traumatic injuries were accounted for according to birds' order and family, monthly and annual distributions, anatomical location, and causes of injury when it was possible to be identified grossly at the necropsies. Bone fractures were classified as complete or incomplete, open (compound) or closed, and simple or comminuted. Affected bones were identified as possible, and the case was classified as polytrauma when three bones or more were fractured.

Samples collection and analysis. All dead or euthanized birds were taken for necropsy. Tissue samples were collected and routinely processed, paraffin-embedded, and stained with hematoxylin and eosin (HE) for histological evaluation. The birds' order and taxonomic identification were performed based on the gross evaluation of external morphological features (van Perlo 2009). The nomenclature of the species was standardized according to the Commented List of Birds of Brazil (Pacheco et al. 2021). Fractures in the thoracic and pelvic limbs were classified as unspecified when information about the affected bone was incomplete in the necropsy records. Other traumatic injuries that did not affect the wings, legs, or skull were classified as miscellaneous. The statistical analysis was performed using the T-test or Chi-square test to compare frequencies of traumatic injuries between the two birds' orders, anatomical locations, and type of fractures (GraphPad Prism 8.01 software).

RESULTS

Epidemiological findings

From 2006 to 2018, 1,711 necropsies in Passeriformes and Psittaciformes birds were retrieved, and 406 cases with incomplete data or nestlings and juvenile birds (that represented an insignificant number of necropsies n=12) were excluded. In the necropsy records from 1305 birds included in this study, 60.8% (794/1,305) were Passeriformes, and 39.2% (511/1,305) were Psittaciformes. Cases of fatal traumatic injuries were detected in 21.8% of birds (285/1305), which included 46.6% (133/285) of Passeriformes and 53.4% (152/285) of Psittaciformes ($p>0.05$). The annual and monthly distributions of cases are represented in Figure 1 and 2, respectively.

The most frequently affected bird species in this study were the yellow-chevroned parakeet (*Brotogeris chiriri*), representing 21.1% (60/285) of all cases, turquoise-fronted amazon (*Amazona aestiva*) 5.6% (16/285), and the great-billed seed finch (*Sporophila maximiliani*) 2.8% (8/285). Among Passeriformes, 36.9% of most injured birds were from the Thraupidae family, 17.2% Turdidae, 13.5% Tyrannidae, 9.0% Furnariidae, 4.5% Icteridae, 3.8% Hirundinidae, 3.8% Mimidae, 2.3% Passeridae, 0.8% Passerellidae, and 0.8% Fringillidae. The family could not be identified in 7.4% of Passeriformes due to the advanced stage of carcass decomposition (Table 1).

Psittaciformes detected with traumatic injuries in this study included 39.5% (60/152) of yellow-chevroned parakeets (*Brotogeris chiriri*), 12.5% (19/152) white-eyed parakeets (*Psittacara leucophthalmus*), 10.5% (16/152) turquoise-fronted amazons (*Amazona aestiva*), 7.2% (11/152) peach-fronted parakeets (*Eupsittula aurea*), 6.6% (10/152) scaly-headed parrots (*Pionus maximiliani*), 5.9% (9/152) yellow-faced parrots (*Alipiopsitta xanthops*), 4.6% (7/152) blue-and-yellow macaws (*Ara ararauna*), 2.0% (3/152) orange-winged amazons (*Amazona amazonica*), 1.3% (2/152) red-shouldered macaws (*Diopsittaca nobilis*), 0.7% (1/152) red-and-green macaw (*Ara chloropterus*), 0.7% (1/152) blue-headed parrot (*Pionus menstruus*), 0.7% (1/152) red-bellied macaw (*Orthopsittaca manilatus*), 0.7% (1/152) caatinga parakeet (*Eupsittula cactorum*), 0.7% (1/152) nanday parakeet (*Aratinga nenday*), and 0.7% (1/152) cobalt-rumped parrotlet (*Forpus xanthopterygius*). The bird species could not be determined in 5.9% of cases (9/152) (Table 2).

Clinical and pathological findings

Blunt trauma was the cause of almost all injuries in this study, and a few cases were predation by a carnivore. There were no significant differences between the frequencies of complete and incomplete ($p>0.05$), open or closed ($p>0.05$), and simple or comminuted fractures ($p>0.05$) in both and between the two birds' orders (Fig.3). According to the anatomical location, the thoracic limbs were affected by

Table 1. Number (N), family and species of Passeriformes birds affected by traumatic injuries

Family	Species	N	Family	Species	N
Thraupidae		49	Furnariidae		12
	Volatinia jacarina	15		*Furnarius rufus*	12
	Sporophila maximiliani	8	Icteridae		6
	Saltator similis	7		*Molothrus bonariensi*	3
	Sicalis flaveola	7		*Gnorimopsar chopi*	2
	Sporophila angolensis	3		*Cacicus haemorrhous*	1
	Sporophila nigricollis	2	Hirundinidae		5
	Dacnis cayana	1		*Pygochelidon cyanoleuca*	3
	Emberizoides herbicola	1		*Progne tapera*	1
	Paroaria dominicana	1		*Pygochelidon melanoleuca*	1
	Sporophila lineola	1	Mimidae		5
	Tachyphonus rufus	1		*Mimus saturninus*	5
	Tangara palmarum	1	Passeridae		3
	Tangara sayaca	1		*Passer domesticus*	3
Turdidae		23	Passerellidae		1
	Turdus rufiventris	17		*Zonotrichia capensis*	1
	Turdus amaurochalinus	4	Fringillidae		1
	Turdus fumigatus	1		*Spinus magellanicus*	1
	Turdus leucomelas	1	-	Not identified	10
Tyrannidae		18			
	Pitangus sulphuratus	14			
	Megarynchus pitangua	1			
	Sirystes sibilator	1			
	Tyrannus melancholicus	1			
	Tyrannus savana	1	TOTAL		133

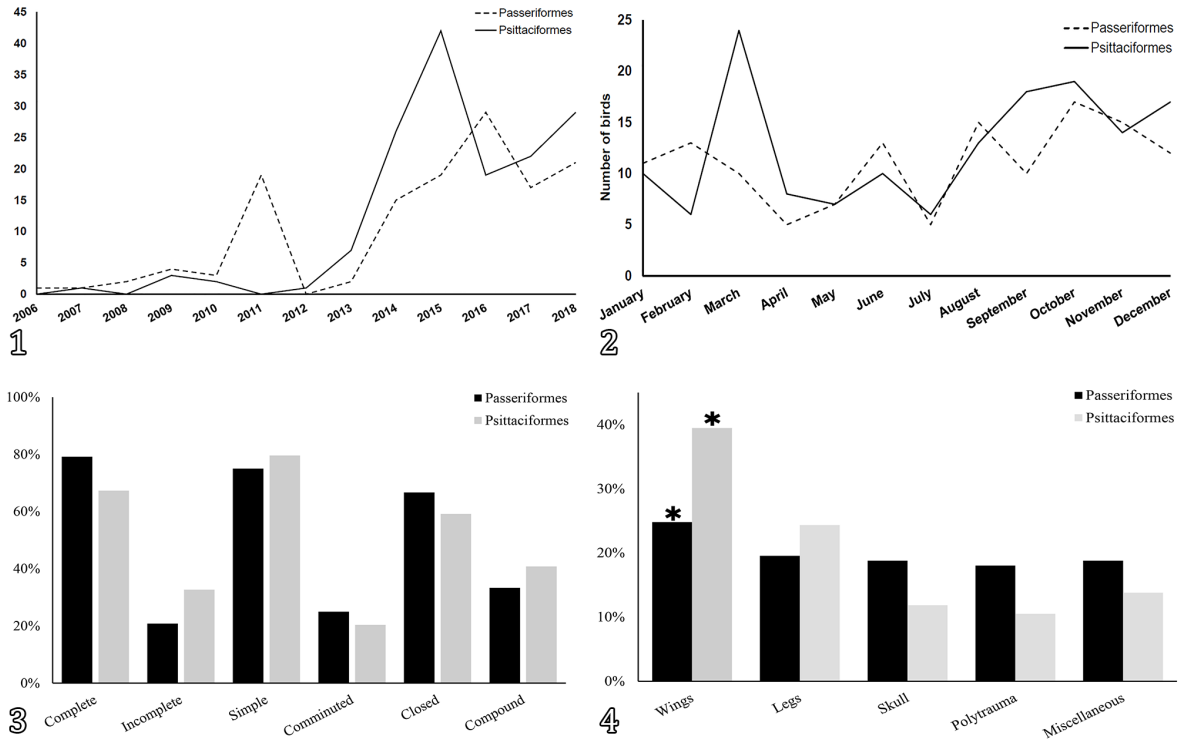

Fig.1-4. Distrito Federal and surrounding areas. (**1**) Annual distribution of birds with fatal traumatic injuries from 2006 to 2018. (**2**) Monthly distribution of birds with fatal traumatic injuries from 2006 to 2018. (**3**) Frequencies of bone fracture types in Passeriformes and Psittaciformes from 2006 to 2018. (**4**) Frequencies of anatomical locations affected by traumatic injuries in Passeriformes and Psittaciformes. *Significative difference between the bird's orders (p<0.05).

traumatic injuries in 32.6% (93/285) of birds, the pelvic limbs in 22.1% (63/285), 16.2% (46/285) miscellaneous, 15.1% (43/285) the skull, and 14.0% (40/285) polytrauma. Trauma was more frequent in the wings of Psittaciformes than Passeriformes (p>0.05) (Fig.4).

Regarding injured bones (Fig.5), humeral fractures were observed in 13.7% (39/285) of the bird, followed by fractures in the radius and ulna in 11.6% (33/285) (Fig.6), carpometacarpus in 4.2% (12/285) (Fig.7), and phalanges in 2.1% (6/285). Fractures in the humerus and radius, and ulna were similar in frequency (p>0.05), but they were more frequent than in the carpometacarpus and phalanges (p<0.05). No differences were observed in the frequency of fractures in the bones of the thoracic limbs between the two bird's orders (p>0.05).

The most frequently traumatic injured bones in the pelvic limbs were the tibiotarsus in 8.1% (23/285) of birds (Fig.8 and 9), followed by digits in 6.6% (19/285), the femur in 4.9% (14/285), and tarsometatarsus in 1.4 % (4/285). In Passeriformes, the frequency of fractures in the digits was higher than in Psittaciformes (p<0.05) (Fig.5). Luxations were observed in a few Psittaciformes in the tibiofemoral (1.3%, 2/152), coracohumeral (1.3%, 1/152), and coxofemoral (0.1%, 1/6) joints.

Subdural hemorrhage had a frequency of 12.3% (35/285) (Fig.10 and 11), representing 14.3% (19/133) of the traumatic injuries in Passeriformes and 10.5% (16/152) in Psittaciformes (p>0.05). Fractures in the skull were detected in 5.7% (5/133) of Passeriformes, affecting the frontal (1.5%, 2/133), temporal (0.7%, 1/133), occipital (0.7%, 1/133), temporal and occipital (0.7%, 1/133), and frontal, parietal, and temporal bones (0.7%, 1/133). In Psittaciformes, fractures in the skull (1.3%, 2/152) were observed in the temporal (0.6%, 1/152) and frontal (0.6%, 1/152) bones.

Miscellaneous traumatic injuries observed in Passeriformes birds included not-specified anatomical locations 11.3% (15/133), predation by domestic carnivores 5.2% (7/133), spinal cord trauma 1.5% (2/133), and trauma in the keel and sternum 0.7% (1/133). In Psittaciformes, the not-specified anatomical location was 7.9% (12/152), predation by domestic carnivores 4.6% (7/152), electrothermal injury 0.6% (1/152), and trauma in the keel and sternum 0.6% (1/152). Polytrauma was similarly recorded in Passeriformes (18.0%, 24/133) and Psittaciformes birds (10.5%, 16/152) (p>0.05). Microscopically, the most significant findings were hemorrhages surrounding trauma sites and tissues around bone fractures.

Table 2. Number (N) and species of Psittaciformes birds affected by traumatic injuries

Species	N
Brotogeris chiriri	60
Psittacara leucophthalmus	19
Amazona aestiva	16
Eupsittula aurea	11
Pionus maximiliani	10
Alipiopsitta xanthops	9
Ara ararauna	7
Amazona amazonica	3
Diopsittaca nobilis	2
Ara chloropterus	1
Pionus menstruus	1
Orthopsittaca manilatus	1
Eupsittula cactorum	1
Aratinga nenday	1
Forpus xanthopterygius	1
Not identified	9
TOTAL	152

DISCUSSION

Anthropogenic matrices may offer many challenges for the birds' flight and survival, such as electrical networks, large glass buildings, heavy vehicle traffic, predation by companion animals, hunting, few afforested and feed areas, and many others. In this scenario, traumatic injuries observed in this study represented a significant cause of death in birds in the Brazillian Cerrado. Some considerations are required to interpret these findings adequately based on the possibilities and variables that could influence our results. As of 2014, a necropsy was instituted as mandatory for all animals that die at the CETAS, IBAMA, and this fact possibly justified the increase in the number of animals received and evaluated in this study (Brasil 2014). In addition, agriculture expansion and destruction of natural habitats have presented a significant rise in the region in the last ten to fifteen years (Ferreira et al. 2016), and they possibly may have contributed to the increase in mortality rates in bird populations (including traumatic injuries) due to environmental anthropization.

Traumatic injuries were more frequently observed in birds from October to March. This period comprises the warmer and rainy months in the region, coinciding with springer and summer, respectively. The reproductive period of most Passeriformes and Psittaciformes birds in Brazil is characterized by a pronounced seasonality concentrated mainly between the spring and summer (Carvalho-Roel & Marçal Júnior 2021, Fornazari et al. 2021). In a study in Central Brazil, wildlife roadkills, including birds, were also more frequent in the rainy season (Fraga et al. 2022), suggesting a seasonality that overlaps the birds' reproductive season in the region. In contrast, traumatic injuries in wild birds were more frequent

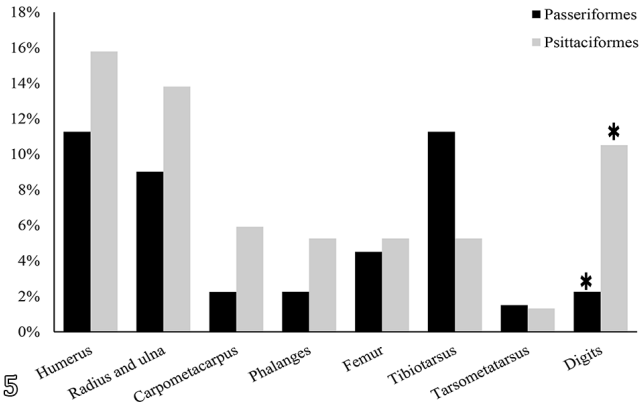

Fig.5. Distrito Federal and surrounding areas. Frequencies of bones with fractures in the thoracic and pelvic limbs of Passeriformes and Psittaciformes from 2006 to 2018. *Significative difference between the bird's orders (p<0.05).

in the autumn, winter, and spring in the North of Portugal (Garcês et al. 2019). A well-determined seasonality in the reproductive period in birds of Brazil may explain an increase in the activity and displacements in search of mating and food, which could provide more risks for developing traumatic injuries. Variations in the reproductive period in different bird

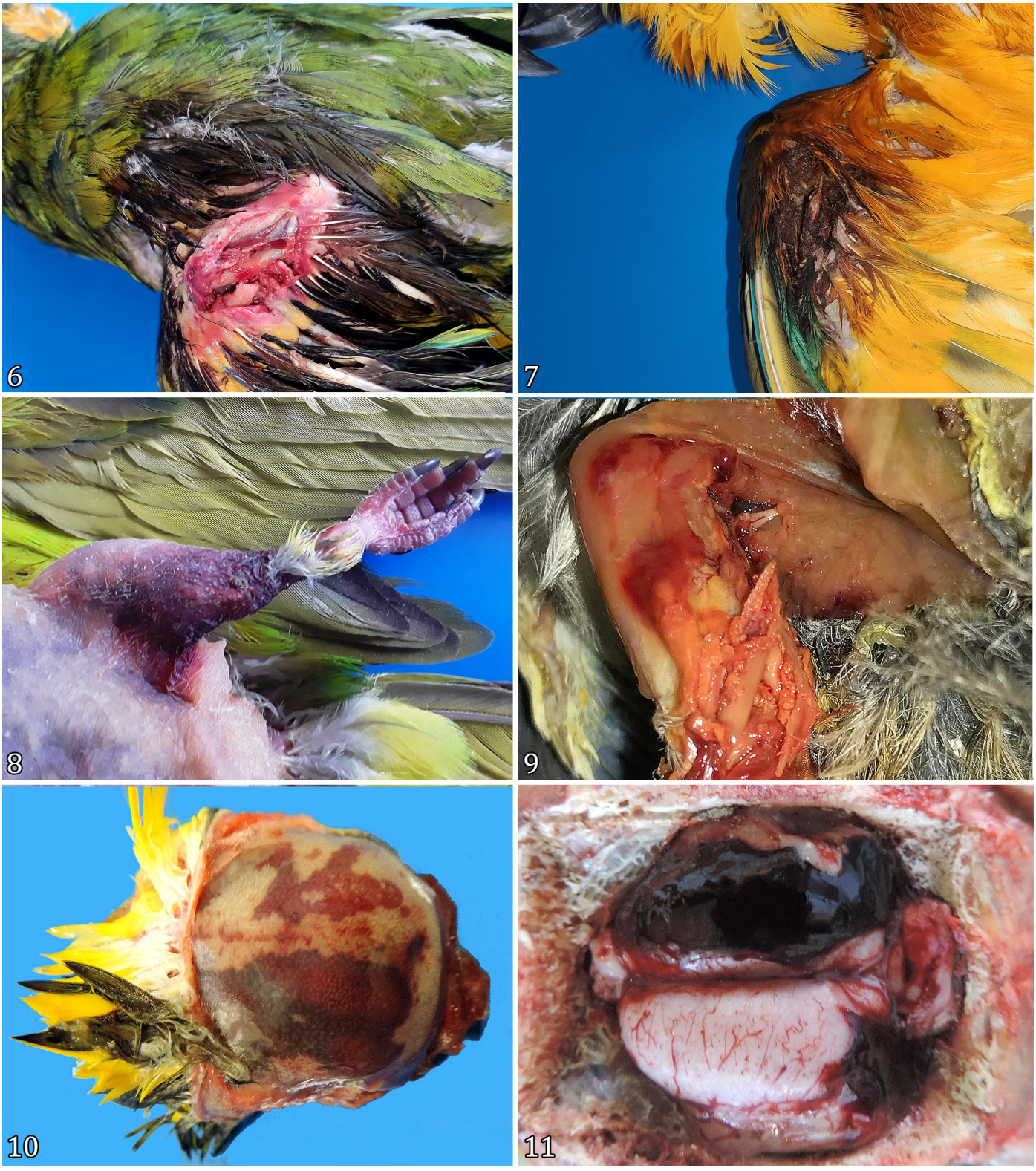

Fig.6-11. Distrito Federal and surrounding areas. (**6**) *Alipiopsitta xanthops*. Right thoracic limb, open fracture in the radius and ulna. (**7**) *Ara ararauna*. Right thoracic limb, open fracture in the carpometacarpus. (**8**) *Amazona aestiva*. Left pelvic limb, closed fracture in the tibiotarsus. (**9**) *Turdus rufiventris*. Right pelvic limb, open fracture in the carpometacarpus. (**10**) *Brotogeris chiriri*. Skull, severe bruise. (**11**) *Brotogeris chiriri*. Skull, subdural hemorrhage.

species, environments, and geographical locations worldwide may promote other behaviors and threats that may interfere with the frequency of traumas.

In our study, traumatic injuries, as a significant cause of death, had a similar frequency in both bird orders and those detected in birds seized from the illegal trade (19.0%) in São Paulo, Brazil (Godoy & Matushima 2010). In the Rio Grande do Sul State, a survey showed trauma as the second cause of death in wild birds (Echenique et al. 2020). Traumatic lesions were the major cause of death in birds of Portugal (57.0%), and Passeriformes were the most affected order (28.7%) (Garcês et al. 2019). In a survey in Leipzig, Germany, 62.0% of free-living birds in urban areas showed traumatic lesions, and 37.0% were Passerine (Stenkat et al. 2013). Lethal traumas ranged from 71.0 to 82.0% in surveys of deaths in Falconiformes in the United States of America (Deem et al. 1998, Harris & Sleeman 2007). Trauma and trauma related-deaths had an incidence of around 80.0% in wild birds from the Galápagos Archipelago, Ecuador (Gottdenker et al. 2008).

Only fatal cases of traumatic injuries in birds taken for necropsy were evaluated in this study, which could explain differences in the frequencies recorded in other reports. The smaller body size and fragility of Passerines' skeletal tissues compared to Psittacines are expected conditions that could facilitate the rise of fractures, more severe traumatic bone injuries, and a worse prognosis. It is also important to consider that trauma-related hemorrhages due to fractures and tissue injuries commonly detected in both bird orders possibly contributed to mortality. Although we have not detected differences between Passeriformes and Psittaciformes in this study, when evaluating and comparing the frequency of traumatic injuries in different conditions and geographical locations, the abundance and dispersion of bird orders, feeding and displacement habits, and other undetermined variables must be considered.

The yellow-chevroned parakeet (*Brotogeris chiriri*) was the most frequently affected bird species in the Distrito Federal and surrounding areas. This bird species is abundant in urbanized and natural areas in the Brazilian Cerrado and possibly justifies the high frequency of traumas detected in these parakeets (Pascotto et al. 2012). No significant differences were observed in our survey between the type of fractures and between bird orders. Fractures are among the most frequent causes of death in Passeriformes and Psittaciformes worldwide (Hager et al. 2017, Wright et al. 2018, Garcês et al. 2019, Carvalho-Roel & Marçal Júnior 2021). Different types of bone fractures may occur, and they undergo so many factors that further broad and specific studies would be necessary to evaluate all variables. Unfortunately, this study did not allow us to assess all these factors.

The thoracic limbs were the most frequently affected anatomical location by traumatic injuries in the Distrito Federal and surrounding areas. Most bone fractures were seen in the humerus, radius, and ulna in the wings and the tibiotarsus, digits, and femur at the pelvic limbs. Generally, traumatic injuries in thoracic limbs have been considered more frequent in wild birds (Harcourt-Brown 2002). In a retrospective case series, fractures in the ulna and radius or the ulna or radius were also the most frequently observed in the thoracic limbs of birds of prey (Vergneau-Grosset et al. 2019). Similar to our findings, tibiotarsal fractures have been reported as a frequent presentation in small bird species with trauma (Wright et al. 2018).

Regarding the pelvic limbs, femoral fractures, as observed in birds in our study, were also common traumatic bone injuries in raptors. In a retrospective in North America, femoral fractures have been considered a common injury associated with a poor prognosis in free-ranging birds of prey (Vigneault et al. 2021). Fractures of the tibiotarsus are among the most frequent in birds. However, the low frequency of trauma in the tarsometatarsus may be explained by the conformation of local joints, which promote the absorption and reduction of impact forces (Orlowski & Siembieda 2005). Microbial contamination, infections, and poor prognosis have been related to communication between the pneumatic foramina, air sacs, and lungs in the bone fractures of birds (Tardón Bermell et al. 2021). Considering our findings in this study, fractures in the thoracic limbs are among the most disabling injuries and pose risks to survival and enable a fatal outcome. Furthermore, luxation was not a relevant traumatic lesion related to the death of birds in this study.

Variations in the anatomical locations of traumatic injuries may be related to numerous causes, factors, and variations between bird orders. In a study in Ecuador, vehicular trauma and human aggression were the most frequent causes of death of wild birds (Gottdenker et al. 2008). Roadkill was also a relevant cause of mortality in birds of the Brazilian Cerrado (Miranda et al. 2020). In contrast, most causes of traumatic injuries have been indeterminate in birds of Portugal (Garcês et al. 2019), as also observed in birds in the Distrito Federal and surrounding areas. Determining causes of blunt trauma in necropsies without a medical history, location, and circumstances of the death is a challenge. As observed in our study, causes of lethal trauma in birds were also not determined in Europe, South, and North America due to the lack of information when they were collected (Deem et al. 1998, Gottdenker et al. 2008, Stenkat et al. 2013, Garcês et al. 2019).

This study found the skull to be the third most affected anatomical site by traumatic injuries such as subdural hemorrhages and fractures. Head traumas are usually immediately lethal and a common cause of death in birds (Loss et al. 2014, Carrasco 2019). Collisions with windows have been reported as a significant cause of trauma in the head (Veltri & Klem 2005), and collisions with vehicles resulted in trauma to the wings and femur (Cousins et al. 2012). A study in Colombia showed that collisions with glass windows accounted for 88% of the causes of trauma in birds (Agudelo-Álvarez et al. 2010). In North America, large buildings with many glass windows strongly correlate with increased collisions and deaths of free-living birds in urban environments (Hager et al. 2017).

Hemorrhages detected in the skull in this study may be related to the high strength of the head bones to traumatic injuries and the intensity and source of traumatic impacts, which promoted the rupture of blood vessels without causing bone fractures. Urbanization, buildings, and excessive lighting are possible risks for birds, increasing the chance of head injuries (Fornazari et al. 2021). Many artificial obstacles and glass windows in heavily urbanized regions, such as the Distrito Federal and surrounding areas, can threaten the flight and displacement of birds, increasing the risks for trauma-related injuries.

Among miscellaneous traumatic injuries, the predation of birds was also a significant cause of death. Previous traumatic injuries and other debilitating diseases can impair the ability to fly, increasing the vulnerability of birds to predators (Carrasco 2019). Predation by dogs or cats can cause fractures in small birds and has been associated with poor prognoses (Wright et al. 2018). Predation by wild carnivores and birds of prey can be considered a common and natural cause of death in free-ranging birds, but the predation rate in the region has not yet been determined. Therefore, our findings could not provide a conclusion on the impact of these traumatic injuries on local bird populations.

Polytrauma was more frequent in Passeriformes than in Psittaciformes birds. In some reports, polytrauma has been observed as a cause of death in raptors (Deem et al. 1998, Harris & Sleeman 2007). The Passeriformes order generally comprises birds with lower body mass and fragile bones to collisions (Silva et al. 2018), which could explain the tendency of more polytraumatized animals in this order. In addition, depending on the causes of the first crash, secondary collisions possibly contribute to cases of polytrauma (Carrasco 2019), as observed in both bird orders in this study.

CONCLUSION

Habitat loss significantly contributes to the decline and extinction of wild populations and must be a concern for the birds' fauna conservation, particularly in the Brazilian Cerrado Biome. Our study showed that traumatic injuries in the thoracic, pelvic limbs, and skull are significant causes of fatalities in wild birds. Further research is needed to understand better the impact of human-driven land use changes and anthropogenic matrices on the survival of birds in the Cerrado Biome.

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Conflict of interest statement.- The authors declare that there are no conflicts of interest.

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