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RETROSPECTIVE STUDY OF MORBIDITY AND MORTALITY OF RAPTORS ADMITTED TO COLORADO STATE UNIVERSITY VETERINARY TEACHING HOSPITAL DURING 1995 TO 1998

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ABSTRACT: A retrospective study was conducted to identify causes of morbidity and mortality of free-living raptors in northeast Colorado and the surrounding areas of Nebraska and Wyoming. The study included 409 raptors, representing 23 species, admitted to the Colorado State University Veterinary Teaching Hospital, Fort Collins, Colorado, USA, from 1995 to 1998. Causes of morbidity and mortality were identified as trauma (66.3%), orphaned young (15.6%), unknown (9.0%), infectious disease (4.4%), metabolic and nutritional disease (2.2%), toxicosis (2.0%), and degenerative disease (0.5%). Trauma was the most frequent cause of morbidity and mortality for all species and during all seasons.

Key words: Colorado, Falconiformes, morbidity, mortality, Nebraska, retrospective study, Strigiformes, Wyoming.

INTRODUCTION

Interest in causes of morbidity and mortality of free-living raptors has increased (Morishita et al., 1998). Reasons for such attention include decline in wild populations and concern about disease and death in captive birds of prey (Cooper and Greenwood, 1980). Direct analysis of these factors in wild populations is difficult to perform because most deaths go unobserved and those that are observed are biased toward an association with human activities or habitation (Newton, 1980). Review of the causes of morbidity and mortality in free-living raptors presented to rehabilitation facilities can provide insight into the health status of wild populations. We surveyed causes of mortality and morbidity of raptors admitted to Colorado State University Veterinary Teaching Hospital, Fort Collins, Colorado, USA, from 1995–98.

MATERIALS AND METHODS

Original medical records of 452 raptors presented to the Colorado State University Veterinary Teaching Hospital from 1995–98 were examined. Forty-three records were eliminated from the study because the birds were captive, the medical records were determined to be incomplete by the Medical Record Department of the Veterinary Teaching Hospital (i.e., medical forms were incomplete, unsigned, or missing), or the records were completely missing. Relevant data from the remaining 409 records were organized into a computerized database (Microsoft Access 2000, Microsoft Corporation, Redmond, Washington, USA). Information collected included the medical case identification number, species, admission date, site/city and state found (Colorado, Nebraska, Wyoming), and clinical or pathologic diagnosis.

Diagnoses were classified into morbidity and mortality categories that included trauma, toxicosis, infectious disease, metabolic and/or nutritional disease, orphaned young, degenerative disease, neoplasia, or unknown/undetermined. Trauma was subdivided into collision, electrocution, gunshot, leg-hold trap, predation, or cause unknown. Collision traumas were further subdivided into impacts with motor vehicles, buildings, powerlines, fences, other, and unknown. Primary causes of morbidity and mortality classifications were based solely on definitive diagnoses; traumas of unknown origin were classified as unknown traumas, and tentative or suspected clinical diagnoses were classified as unknown/undetermined.

The medical diagnoses were determined by the attending clinician or pathologist and were based on the case history, physical examination, any ancillary diagnostic tests, and/or gross necropsy findings and histopathologic examination.

All cases received a complete physical examination. Complete blood cell counts and chemistry panels were performed on 202 birds. Gross necropsy and histopathologic examination were performed on 176 of 245 animals that died or were euthanized. The diagnosis of organophosphate/carbamate intoxication was based on reduced blood or tissue levels of acetylcholinesterase in combination with clinical signs and lesions compatible with the intoxicant. Lead poisoning was based on blood lead levels > 0.2 ppm and consistent clinical signs (Deem et al., 1998). Infectious disease was defined as cases in which a pathogenic organism was isolated or identified by microbiologic or parasitologic techniques (e.g., *Trichomonas* sp. were identified by the microscopic examination of wet mounted smears of oral lesions or crop contents) or cases with gross or histopathologic lesions indicating an infectious disease process (suppuration, necrosis, inflammatory cell infiltrates, or presence of an infectious organism). Orphaned young were defined as infant or juvenile animals that were otherwise healthy but unable to survive in the wild unassisted. Degenerative disease was determined by clinical, radiographic, or necropsy findings of conditions such as arthritis.

RESULTS

Twenty-three species (Table 1) from two orders and five families were included. Differentiation between the Western screech owl (*Otus kennicottii*) and Eastern screech owl (*O. asio*) was seldom made in the medical records; therefore, the two species were combined and identified simply as screech owls. Medical records of one hawk and three owls did not identify the species; therefore, they were identified as unknown species.

Trauma (66.3%) was the most frequently observed cause of morbidity/mortality (Table 1). Orphaned young (15.6%) was the second most frequent cause, followed by unknown/undetermined (9.0%). Infectious disease (4.4%), metabolic/nutritional disease (2.2%), toxicosis (2.0%), and degenerative disease (0.5%) were less frequent causes of morbidity/mortality. No case of neoplasia was seen.

Causes of morbidity and mortality were similar among species (Table 1). The leading cause for all species was trauma. Second most common causes of morbidity and mortality were considered in species with a large sample size ($n > 30$). Orphaned young was the second most common cause of morbidity/mortality for American kestrels (*Falco sparverius*) (21%), great horned owls (*Bubo virginianus*) (14%), and Swainson's hawks (*Buteo swainsoni*) (19%). However, the next most common causes of morbidity and mortality of red-tailed hawks were toxicoses (13%) or were unknown/undetermined (13%).

Trauma was the most frequent cause of morbidity and mortality during all seasons (Table 2). The second most common causes were orphaned young during spring (March–May) and summer (June–August), unknown/undetermined during fall (September–November), and toxicosis in winter (December–February). The number of admissions were greatest during the spring and summer months.

Of the 271 birds presented for trauma, 186 (68.6%) injuries were due to unknown trauma, 50 (18.5%) injuries were due to collision-related trauma, and 16 (5.9 %) injuries were related to predation. Other traumas included 11 (4.1%) electrocutions, six (2.2%) gunshot wounds, and two (0.7%) leg-hold trap injuries. Collision-related traumas consisted of collisions with motor vehicles (22), fences (11), buildings (10), other (4), unknown (2), and powerlines (1). Other traumas consisted of collisions with a hatchery net, a kite string, a water tank, and one bird caught in a hailstorm. Of the traumas due to predation, nine were attributed to attacks by cats, three to dogs, one to birds, and one unknown predator.

The most common infectious diseases diagnosed were trichomoniasis (44%), avian pox (17%), and pneumonia/air sacculitis (17%). Infectious disease was most frequently seen in cases admitted during the summer (61% of 18 cases). Of the nine metabolic/nutritional disease-related morbidities and mortalities, emaciation (67%) was seen most frequently. The most common intoxicants were organophosphates/

TABLE 1. Morbidity and mortality of raptors presented to the Colorado State University Veterinary Teaching Hospital, Fort Collins, Colorado, 1995–98.

		Diagnosis (%)											
Species	Number (%)	Unknown trauma	Collision	Predation	Electrocution	Gunshot	Leg-hold trap	Orphaned young	Unknown/undetermined	Infectious disease	Metabolic/nutritional disease	Toxicosis	Degenerative disease
Red-tailed hawk (*Buteo jamaicensis*)	31 (7.6)	42	0	0	0	6	3	10	13	10	0	13	3
Swainson's hawk (*Buteo swainsoni*)	37 (9.0)	48	16	0	3	0	0	19	8	0	3	3	0
Rough-legged hawk (*Buteo lagopus*)	8 (2.0)	63	0	0	13	13	0	0	13	0	0	0	0
Ferruginous hawk (*Buteo regalis*)	9 (2.2)	11	67	0	11	0	0	0	11	0	0	0	0
Northern harrier (*Circus cyaneus*)	6 (1.5)	66	0	0	0	0	0	17	17	0	0	0	0
Golden eagle (*Aquila chrysaetos*)	18 (4.4)	28	6	0	0	6	0	22	11	11	0	17	0
Bald eagle (*Haliaeetus leucocephalus*)	5 (1.2)	80	0	0	0	0	0	0	20	0	0	0	0
Cooper's hawk (*Accipiter cooperii*)	5 (1.2)	60	0	0	0	0	0	20	20	0	0	0	0
Sharp-shinned hawk (*Accipiter striatus*)	13 (3.2)	62	8	15	0	0	0	0	15	0	0	0	0
American kestrel (*Falco sparverius*)	126 (30.8)	40	9	8	2	1	0	21	7	8	3	0	1
Merlin (*Falco columbarius*)	2 (0.5)	100	0	0	0	0	0	0	0	0	0	0	0
Prairie falcon (*Falco mexicanus*)	8 (2.0)	75	0	0	0	0	0	0	13	0	13	0	0
Peregrine falcon (*Falco peregrinus*)	3 (0.7)	67	0	0	0	0	0	0	0	33	0	0	0
Turkey vulture (*Cathartes aura*)	1 (0.2)	100	0	0	0	0	0	0	0	0	0	0	0
Great horned owl (*Bubo virginianus*)	85 (20.8)	46	20	1	6	1	1	14	7	1	3	0	0
Long-eared owl (*Asio otus*)	12 (2.9)	67	33	0	0	0	0	0	0	0	0	0	0
Short-eared owl (*Asio flammeus*)	3 (0.7)	67	33	0	0	0	0	0	0	0	0	0	0
Screech owl (*Otus kennicotti* or *O. asio*)	12 (2.9)	42	0	8	0	0	0	34	8	8	0	0	0
Northern saw-whet owl (*Aegolius*)	7 (1.7)	43	14	14	0	0	0	0	14	0	14	0	0
Flammulated owl (*Otus flammeolus*)	2 (0.5)	100	0	0	0	0	0	0	0	0	0	0	0
Burrowing owl (*Athene cunicularia*)	1 (0.2)	100	0	0	0	0	0	0	0	0	0	0	0
Barn owl (*Tyto alba*)	11 (2.7)	27	9	0	0	0	0	37	27	0	0	0	0
Owl (Unknown species)	3 (0.7)	0	0	33	33	0	0	33	0	0	0	0	0
Hawk (Unknown species)	1 (0.2)	100	0	0	0	0	0	0	0	0	0	0	0

TABLE 2. Morbidity and mortality of raptors admitted to the Colorado State University Veterinary Teaching Hospital by season, 1995–1998.

Season	Number	Diagnosis (%)						
		Trauma	Orphaned young	Unknown/-undetermined	Infectious disease	Metabolic/nutritional disease	Toxicosis	Degenerative disease
Spring (Mar.–May)	90	67	18	10	4	1	0	0
Summer (June–Aug.)	188	60.1	23.9	6.4	5.9	2.7	0.5	0.5
Fall (Sept.–Nov.)	77	73	4[a]	16	2	4	3	0
Winter (Dec.–Feb.)	54	78	0	7	4	0	9	2

[a] Three raptors presented as orphaned young during the fall season were atypical presentations. Two birds were orphaned young transferred to the VTH from another rehabilitation center. The remaining bird was an inexperienced first-year Swainson's hawk.

carbamates (five of eight cases) and lead (two of eight cases). Toxicosis was most commonly seen during the fall and winter seasons (Table 2).

DISCUSSION

The majority of raptors in this study were presented for trauma-related morbidity or mortality. This is consistent with similar studies by Coon et al. (1969), Stewart (1969), Cooper (1973), Clausen and Gudmundsson (1981), Redig et al. (1983), Fix and Barrows (1990), Work and Hale (1996), Deem et al. (1998), and Morishita et al. (1998). These results are in contrast with finding trauma in only 5% of 92 free-living British kestrels (*Falco tinnunculus*) (Keymer et al., 1980).

Humans directly contributed to at least 23% of the 271 trauma cases and may have been responsible for more due to undocumented motor vehicle collisions. Predominance of human-caused mortalities is consistent with Keran's (1981) comparison of human-caused and naturally occurring raptor mortalities. Retrospective studies likely over-represent human associated injuries, such as motor vehicle collisions, because injured raptors are most frequently recovered in areas associated with human activity.

Gunshot trauma (1.5% of all causes) was less common a cause of morbidity or mortality compared with earlier studies (Stewart, 1969; Clausen and Gudmundsson, 1981; Deem et al., 1998). A very low prevalence of leg-hold trap trauma (0.5%) was also seen in this study. These findings may indicate successful public education and legal protection due to Endangered Species Act of 1973, the Convention on International Trade in Endangered Species of Wild Flora and Fauna of 1973 and constraints placed on the use of leg-hold traps in Colorado in 1997.

Low prevalence of electrocution in this study may be attributed to several factors. Electrocution victims often die immediately and usually go unnoticed unless found in an area with frequent human activity. These raptors would less likely be presented to a rehabilitation facility for treatment and are likely under represented. Raptor electrocutions may also be declining in certain areas of Wyoming due to design changes made in powerline structures to reduce the risk of electrocution of birds of prey (Harness and Garrett, 1999).

The second most frequent cause of morbidity and mortality was orphaned young (15.6%) which occurred during the spring and summer seasons. Orphaned young were also the second most common cause of morbidity and mortality in raptors from Iowa (Fix and Barrows, 1990). The second most common cause of morbidity and mortality in raptors from California (Morishita et al., 1998) and Florida (Deem et al., 1998) was infectious disease (30%) and toxicosis (6.2%) respectively. The low prevalence of infectious disease and toxicoses in this study may be due to the presence of multiple morbidity and mortality factors. Sublethal infectious diseases and toxicosis may play a role in trauma-associated morbidity and mortality (e.g., electrocution, car or building strike) by predisposing the birds to injury. Therefore, raptors that present for trauma may have an underlying condition that is missed by the attending clinician. In addition, only definitive cases of infectious disease and toxicosis were used in this study. Many suspected toxicosis cases were not confirmed and thus were classified as unknown or undetermined resulting in under-representation of these problems. Mineau et al. (1999) suggested the prevalence of pesticide poisoning in raptors is much higher than currently documented. While the prevalence of infectious disease and toxicosis in Colorado may actually be low, more extensive use of laboratory diagnostics would aid in providing additional documentation of the prevalence of infectious disease and toxicosis in raptors presented for medical treatment.

Feeding habits and body size of raptors may influence the risks for certain causes of morbidity and mortality. These factors can also influence the probability a raptor will survive until it is recovered as well as the chance that the bird will be recovered for rehabilitation; for example, the documented cases of toxicosis in this study were in broad-winged hawks and eagles. The majority of gunshot trauma cases were large hawks and owls. The increased visibility of large raptors, and other anthropogenic reasons, likely increased their risk of such injury. Electrocution cases were primarily large hawks and owls but also included small falcons. Transformers are frequently responsible for electrocution of small raptors, while larger birds are prone to injury by a wider range of utility structures (Harness, 1997). In contrast, some causes of morbidity and mortality appear to have little association with size and species of raptors; for example, collision trauma and orphaned young were seen in a variety of species.

Examining morbidity and mortality of raptors will remain an important method for monitoring changes in environmental health as well as assisting clinicians treating these animals. Predators such as raptors are known to bioaccumulate environmental contaminants and may be good indicator species of these problems (Cooper and Greenwood, 1980). Causes of morbidity and mortality in wild raptor populations are difficult to monitor because collection of unbiased data rarely is possible and, even though the immediate cause of death may be accurately diagnosed, the underlying causes of death often are unknown (Newton, 1980). Determination of causes of morbidity and mortality of raptors presented to rehabilitation facilities can, however, provide some insight into these factors in wild populations, providing the biases of such data are acknowledged. The major problems faced by raptor populations appear to have changed from intoxication in the 1960's and 1970's to human-associated traumas in the 1990's (Deem et al., 1998). However, toxins may still play an important role in multifactorial causes of morbidity and mortality in raptors (Mineau et al., 1999).

An accurate and complete history of free-living raptors admitted to rehabilitation centers is vital in documenting causes of morbidity and mortality in wild populations. Thorough examination and diagnostic testing in live raptors and necropsy of those that die are fundamental in providing accurate diagnoses.

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