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2018

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OSTEOARTHRITIS IN THE PELVIC LIMB OF CAPTIVE CRANES

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Abstract: We conducted an epidemiological study of osteoarthritis (OA) among the 15 captive crane species managed at the International Crane Foundation from 1973 to 2016. A retrospective review of 714 medical records found 37 cases of OA in 13 species of cranes and a corresponding period prevalence of OA of 5%. An analysis of the living captive crane flock as of 1 October 2016 ($n = 115$) found 12 active cases of OA (a point prevalence of 10%), and there was a statistical association between geriatric age classification (i.e., advanced age) and the presence of OA ($P < 0.01$). The mean age of cranes with OA was 14 years greater than cranes without the disease ($P < 0.001$). The prevalence estimates of OA from this review were somewhat lower than that from study of museum specimens, but this study similarly identified the tarsal joint as the predominant location of OA lesions in cranes.

PROCEEDINGS OF THE NORTH AMERICAN CRANE WORKSHOP 14:145-148

Key words: captivity, cranes, epidemiology, incidence, Gruidae, joint, osteoarthritis, prevalence, prevention.

Osteoarthritis (OA) is defined by the bony remodeling of a synovial-lined joint and may result in formation of bony projections along joint margins (osteophytes), degeneration or erosion of articular cartilage, fibrosis of joint capsules, and inflammatory changes (Degernes et al. 2011). Osteoarthritis in birds appears to be independent of free-ranging or captive status, morphotype, or body weight (Rothschild and Panza 2006, 2007). The posture of birds, however, may affect frequency of OA due to varied joint-loading (Degernes et al. 2011). Previous trauma, infectious agents, and pre-existing congenital or developmental deformities are also recognized etiologies of OA in captive cranes (Langenberg and Businga 1999).

Although retrospective studies investigating degenerative joint disease in skeletal specimens of birds and captive waterfowl have been performed (Rothschild and Panza 2005), no studies have investigated the frequency of OA among a single captive collection of long-legged birds. The large crane collection at the International Crane Foundation (ICF), Baraboo, Wisconsin, presents a unique resource to begin to assess OA within the Gruidae. The ICF holds individuals of each of the 15 species within this taxonomic family and all are subject to similar environmental management and husbandry. A previous review of the ICF whooping crane (*Grus americana*) population identified several instances of pelvic limb injury that could be causally related to OA later in life, as well as cases of degenerative musculoskeletal disease (Hartup et al. 2010).

Our goal was to conduct a 2-phase epidemiological study of OA cases among the 15 captive crane species at ICF. The study population generally consisted of captive cranes managed for months to several years for zoological exhibition, captive breeding for Species Survival Plan (AZA 2017) participation, and production for domestic reintroduction involving whooping cranes. The first phase consisted of a retrospective review of 43 years of available medical records ($n = 905$) dating from ICF's founding in 1973 to October 2016. Records of juvenile whooping cranes captive-reared and then subsequently transferred for reintroduction were excluded from the review due to their special management ($n = 191$), leaving 714 records for review of OA diagnoses. The period prevalence of OA for each species was calculated as the number of OA cases diagnosed/number of individual cranes at risk during the study period (i.e., no. records reviewed per species). The second phase of the study consisted of an analysis of records of the living ICF captive crane flock as of 1 October 2016 ($n = 115$) to provide a point prevalence estimate of OA (no. active OA cases/115).

Cases of OA were determined based on a confirming description in records from at least 1 of 3 diagnostic modalities: physical examination, radiographic study, and/or necropsy. Physical examination descriptions by a veterinarian consistent with arthritic change included gross changes to an afflicted anatomical site (e.g., joint crepitus, bony enlargement, chronically swollen joints) and changes

in normal movement (e.g., chronic lameness, joint stiffness, decreased range of motion). Osteoarthritis was diagnosed radiographically by the presence of 1 or more of the following: osteophyte formation, loss of joint space, thickening of joint capsules, eburnation, mineralization of peri-articular soft tissues, and other signs of bone remodeling (Degernes et al. 2011). Necropsies of cranes were performed at the University of Wisconsin-Madison School of Veterinary Medicine. Observations such as osteophyte formation, articular cartilage degeneration, eburnation, fibrosis and proliferation of joint capsule(s), or periarticular tissue mineralization were used to confirm OA at necropsy. We collected information on species, sex, age, and anatomical distribution of OA lesions.

We used the following generalized age classifications across all captive cranes: juvenile (<1 year), subadult (1-4 years), adult (5-19 years), and geriatric (20 or more years). These age classifications vary slightly among species and in comparison to wild cranes, which typically achieve reproductive maturity 2 to 3 or more years earlier than captive cranes (Archibald and Lewis 1996).

We found 37 cases of OA in 13 species of cranes from our review of ICF medical records (Table 1). The period prevalence of OA was 5% during the 43-year period covered by the records (Table 2). The greatest species period prevalence and absolute number of cases occurred among Siberian cranes (*Grus leucogeranus*). No OA cases were diagnosed from black crowned (*Balearica pavonina*) or grey crowned crane (*B. regulorum*) records that were reviewed. Most cranes diagnosed with OA were adults (n = 15, 40%) or considered geriatric (n = 20, 54%) at the time of diagnosis; the median age at diagnosis was 20 years. There was a similar number of cases diagnosed in female (n = 20, 54%) and male cranes (n = 17, 46%).

Arthritic change was commonly described involving the tarsal joint (n = 23, 62%) or feet and digits (n = 18, 49%); fewer cases involved the coxofemoral or stifle joints. Osteoarthritis was described as multifocal (affecting multiple joints) in 26 (70%) of cases and involved joints of both limbs in 23 (62%) cases. Two (5%) of the cases were diagnosed on postmortem exam without antemortem confirmation of OA, and each exhibited lesions only in the coxofemoral or stifle joints.

In October 2016, the ICF captive population of 115 cranes included 12 (10%) active cases of OA (6 males and 6 females) from 8 species. All but 1 of the cases existed in a crane of geriatric age class. There was a statistical association between geriatric age classification (i.e., advanced age) and the presence of OA ($\chi^2 = 8.4$, $P < 0.01$) in the population. The mean age of cranes with OA was 14 years greater than cranes without the disease ($t = 4.2$, $P < 0.001$).

A multi-institutional study of museum skeletal specimens reported the prevalence of OA in cranes as greater than 15%; nearly all the specimens were likely of wild origin, but the number of specimens evaluated was not given (Rothschild and Panza 2005). This estimate was lower than several other waterbird taxa, including spoonbills and ibises (Threskiornithidae), herons and bitterns (Ardeidae), and avocets and stilts (Recurvirostridae). We documented a historical period prevalence of 5%, or about 1 OA case for every 20 cranes managed by ICF over the years. We regard the period prevalence an underestimate of OA in the ICF crane population. Some cases likely went undescribed prior to on-site veterinary care instituted in the late 1980s that resulted in greater detailed physical exam records and regular use of diagnostic radiology. There were also large numbers of juvenile sandhill (*Grus canadensis*) and whooping cranes from captive breeding efforts included in the review that died at young ages unlikely to develop OA as chicks.

We found that cranes developed OA typically as older adults, but unexpectedly did not often have a history of pelvic limb injury. We found no sex predilection for OA. Siberian cranes had the greatest period prevalence of OA of any species. This finding is consistent with the view, as expressed by Langenberg and Businga (1999), that there are environmental constraints in captive settings not suitable over the long-term for this highly wetland-adapted species. Wild Siberian cranes spend more time in marshy substrates than other species of cranes and their joint anatomy may not withstand less dynamic surfaces commonly offered at ICF (soil and concrete with bedding), resulting in greater risk of OA among captive specimens.

We found the tarsal joint was most affected by OA compared to other joints in the pelvic limb of captive cranes. Rothschild and Panza (2005) reported that OA predominantly affected the tarsus in captive birds, but other pelvic limb joints were affected, albeit rarely. In this study, the feet and digits were commonly affected

Table 1. Individual characteristics of osteoarthritis diagnosed in 37 cranes at the International Crane Foundation, 1973-2016. OA = osteoarthritis, TMT = tarsometatarsal-phalangeal joints, PE = physical examination, M = male, F = female, Y = yes, N = no, R = right leg, L = left leg, B = bilateral (both left and right legs), X = completed, N/A = lost to follow-up.

Species/ID	Sex	Age	Multifocal OA	OA affected joint(s)					Diagnostic method		
				Coxofemoral	Stifle	Tarsus	TMT	Digits	PE	Radiology	Necropsy
Demoiselle (*Anthropoides virgo)*											
030012	F	16	N					L	X	X	Alive
Blue (*A. paradisea)*											
040007	F	20	N			R				X	N/A
040014	F	13	Y				B		X	X	N/A
Wattled (*Bugeranus regulorum)*											
050010	M	20	Y			R	L		X	X	X
050011	F	47	Y	R	R				X	X	X
Siberian (*Grus leucogeranus)*											
060001	M	78	Y			B				X	X
060004	F	10	Y			B				X	X
060005	F	24	Y			B	L	L	X	X	X
060007	M	17	Y			B	L	L	X	X	
060008	M	18	N			L			X	X	
060009	F	18	Y			B	B		X	X	X
060011	M	20	Y			B			X		X
060022	F	20	N			L			X		
060040	M	19	Y			B			X	X	X
060053	F	3	N					L	X	X	
Sandhill (*G. canadensis)*											
070031	M	20	Y					B	X		Alive
070035	F	32	Y	R	R				X		X
Sarus (*G. antigone)*											
080045	F	24	Y			B	B	B	X	X	
Brolga (*G. rubicunda)*											
090008	M	13	Y					B	X	X	Alive
090015	M	10	N					L	X	X	Alive
White-naped (*G. vipio)*											
100015	M	29	Y		B		B	B	X	X	X
100022	F	36	N			R			X		Alive
100028	M	17	Y			L		B	X	X	Alive
100055	F	19	Y		R		L		X	X	X
Eurasian (*G. grus)*											
110015	F	35	N		R				X	X	X
110016	M	39	Y		B				X	X	X
Hooded (*G. monacha)*											
120022	M	15	Y			L		L	X	X	N/A
120023	M	18	Y			R		L	X	X	X
120033	F	13	Y			B			X		X
Whooping (*G. americana)*											
130007	M	33	Y			B		R	X	X	X
130016	F	28	Y			B		R	X	X	X
130040	M	15	Y			B			X	X	X
130078	F	15	Y		B						X
130113	F	0.5	N	R							X
Black-necked (*G. nigricollis)*											
140003	M	29	N			R			X		Alive
Red-crowned (*G. japonensis)*											
150040	F	31	N			R			X		Alive
150046	F	30	Y			B			X		Alive

Table 2. Period prevalence of osteoarthritis (OA) diagnosed in 15 crane species at the International Crane Foundation, 1973-2016.

Species[a]	OA cases	No. medical records reviewed	Period prevalence (%)
Black crowned	0	16	0
Grey crowned	0	24	0
Demoiselle	1	15	6.7
Blue	2	15	13.3
Wattled	2	29	6.9
Siberian	10	65	15.4
Sandhill	2	127	1.6
Sarus	1	59	1.7
Brolga	2	25	8.0
White-naped	4	47	8.5
Eurasian	2	27	7.4
Hooded	3	43	7.0
Whooping	5	152	3.3
Black-necked	1	25	4.0
Red-crowned	2	45	4.4
Total	37	714	5.2

[a] Black crowned (*Balearica pavonina*), Grey crowned (*B. regulorum*), scientific names of other crane species can be found in Table 1.

by OA as well. Some of these cases were associated with a concrete sill between indoor and outdoor enclosures in exhibit housing thought to have injured 1 or more digits, eventually leading to pedal OA. This environmental feature was subsequently removed and no further cases of pedal OA have been diagnosed in birds on exhibit.

Etiologies underlying the cases of OA that we documented, in order of likelihood, include age-related biomechanical stress from increased longevity in captivity, acute or chronic traumatic injury (Curro et al. 1992, Hartup et al. 2010), congenital or developmental deformities (Langenberg and Businga 1999, Kelley and Hartup 2008), and infectious disease. In many instances, however, there is significant time lag between onset of developmental deformities or episodes of injury and resulting changes in cartilage and biomechanics that would lead to OA, making a link between them tenuous. The goal of our review was not to focus on etiology of OA, but to confirm or deny patterns of disease in this unique zoological collection. Strategies to provide substrate diversity, good quality nutrition and regular health care, while preventing risks for injury, may help to limit OA common among older adult and geriatric cranes.

ACKNOWLEDGMENTS

We thank all previous and current Conservation Medicine and Crane Conservation Department staff for excellent record keeping and care of the captive cranes at ICF.

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