Review of the diseases, parasites and miscellaneous pathological conditions of North American bison

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Abstract

The involvement of veterinarians in the health management of North American bison will continue to increase, particularly in regard to the development of the bison ranching industry. More intensive management of bison will lead to greater recognition of diseases, and will raise concerns about the transmission of diseases between bison and other livestock species. This review of the infectious and noninfectious diseases of free-ranging and captive bison populations indicates that bison are susceptible to a wide range of indigenous and foreign diseases that occur in cattle and other livestock species. Most of the available information is based on necropsy results or serological surveys, and there is much less information on clinical, diagnostic and preventive medicine, or on the evaluation of conventional diagnostic tests, therapeutic regimens, or vaccines in bison.

Résumé

Une revue des maladies, parasitoses et de diverses conditions pathologiques chez le bison nord-américain

L'intervention des vétérinaires dans la régie de la santé du bison nord-américain continuera de croître, particulièrement dans le développement de l'industrie de l'élevage du bison. Une régie plus stricte conduira à une identification plus adéquate des problèmes de santé et des modes de transmission de maladies entre bisons eux-mêmes ainsi qu'à d'autres espèces d'élevage. Cette revue de maladies infectieuses et non-infectieuses affectant des bisons en pâturage libre et des bisons en captivité indique qu'ils sont susceptibles à un grand éventail de maladies indigènes et étrangères qui existent chez le bovin et autres espèces d'élevage. Une grande partie de l'information disponible résulte d'observations ou d'enquêtes faites à la nécropsie. Par contre, les aspects cliniques tels que les méthodes de diagnostic, la médecine préventive, l'évaluation des tests de laboratoire conventionnels, les interventions thérapeutiques et les programmes de vaccination chez le bison, sont peu documentés.

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Introduction

There are an estimated 100,000 plains bison (*Bison bison bison*) in North America (1), and the majority of these animals are privately owned. In most jurisdictions, bison are classified as livestock rather than wildlife. Bison ranching is a growing industry in Canada and the United States, and organizations such as the Canadian Bison Association, American Buffalo Association, and National Bison Association have been established to promote the industry and provide information to producers. The increasingly intensive management of bison, the widespread commercial trade in bison, and increasing opportunities for contact between bison and other livestock have demanded the attention of the veterinary profession from both clinical and regulatory standpoints. The purpose of this review is to provide veterinarians and bison producers with the available scientific information on the diseases and parasites of bison and to identify gaps in the information that should be addressed.

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Bacterial diseases of bison

Brucellosis (Brucella abortus). The first indication of bovine brucellosis in wildlife appeared in the 1917 Report of the Chief of the U.S. Bureau of Animal Industry and dealt with three bison cows from Yellowstone National Park (2). Two of the three bison had aborted and all were positive on *B. abortus* agglutination tests. Creech (2) isolated *B. abortus* from a case of necrotizing orchitis in a bison bull from the National Bison Range in Montana in 1930, and reported that other bison in that herd had orchitis or retained placentas. Rush (3) noted the occurrence of abortions in bison at Yellowstone National Park, and that three of five bison sera tested in 1930 were positive on agglutination tests. He suggested that the disease originated from cattle that had been kept on the bison range until 1919. Agglutination tests on sera collected from bison in Yellowstone National Park in 1931, 1932 and 1933 were positive in 64 of 106 cases, 107 of 199 cases, and 51 of 69 cases, respectively (4). The same authors observed orchitis in one of 26 and six of ten bulls killed at Yellowstone in 1932 and 1933, respectively, and isolated *B. abortus* from two cases. The number of serological reactors in 1932 and 1933 at the National Bison Range were 58 of 87 and 48 of 86 bison sera, respectively.

Bovine brucellosis is still a problem in bison herds in the United States, but little scientific information has been published on the situation. The National Bison Range herd and most other publicly owned herds are now free of the disease, but brucellosis management in Yellowstone National Park is still a point of contention and the disease is present in the free-ranging bison and elk populations in that area (5). The park boundary is under surveillance and bison that stray outside the park are either chased back or shot. In 1982, the U.S. Plant, Animal and Health Inspection Service indicated that brucellosis transmission was becoming a significant problem amongst the 500 to 1000 privately owned

bison herds in the United States (6). However, since then, considerable effort has been made to control and eradicate the disease in these private herds (5). Transmission of brucellosis from bison to cattle initiated an outbreak of the disease in North Dakota (a brucellosis-free state) in 1983 (7).

The first evidence of brucellosis in Canadian wildlife was in bison from Elk Island National Park in Alberta. In 1946–47, sera from 37 of these bison included six positive and five suspicious reactors on tube agglutination tests (8). A 1956 survey at the same park found 111 (32.4%) positive and 34 (11.3%) suspicious reactors on tube and plate agglutination tests of sera from 343 bison (9). The same study reported two positive and one suspicious reactors among 20 bison from Riding Mountain National Park in Manitoba in 1956–57. The report concluded that park-confined bison were not a health threat to cattle but that free-ranging bison, such as those in Wood Buffalo National Park, could be a hazard. Test and slaughter, and calfhood vaccination programs have since eliminated brucellosis from Elk Island National Park. Repeated serological testing by Agriculture Canada, including the 1987–88 herd evaluation, has indicated that the bison population in Riding Mountain National Park is free of brucellosis.

Brucellosis was detected in bison at Wood Buffalo National Park in 1956 when 3 of 11 sera were found positive on agglutination tests (9). Choquette *et al* (10) reviewed the results of serological surveys of the park bison. In eleven collections between 1959 and 1974, tube agglutination tests detected 625 (30.3%) positive and 141 (6.8%) suspicious reactors out of 2,066 bison sera. Sera collected from bison at Hook Lake, Northwest Territories (outside the park) in 1970 and 1974 included 114 (38.1%) positive and 16 (5.4%) suspicious reactors among 299 samples. Cases of orchitis and arthritis were observed in park bison and *B. abortus* was cultured from some of these lesions. The authors suggested that brucellosis could well be a factor in the poor reproductive rate of the park herd. A recently completed study of bison in the park region found evidence of brucellosis in 18 (25%) of 72 bison (11). No efforts have been made to eradicate brucellosis in the bison at Wood Buffalo National Park or the Slave River Lowlands, and thus they remain the only known infected bison population in Canada. The disease was discovered in a privately owned herd of bison in Ontario in 1988, and the herd was immediately quarantined and then slaughtered.

Tuberculosis (Mycobacterium bovis). Reports of diseases in wild bison are extremely rare in the voluminous historical literature on these animals (12,13). In 1909, Seton (14) quoted Charles Aubrey as saying, "I have frequently examined [bison] lungs, but never found any symptoms of tuberculosis or other affection of the lungs." Tuberculous lesions in bison were documented in slaughter reports from the herd at Buffalo National Park near Wainwright, Alberta. This herd was established in 1909 and Hadwen (15) indicated that tuberculosis was first recognized in surplus animals that were slaughtered in 1923. However, unpublished reports of the Parks Branch of the Department of the Interior indicate that the first case was reported on December 20, 1916, and additional cases were reported on March 20, 1919, and on April 13, 1920. Between 1923 and 1937, 6,450 (53.7%) of the 12,005 surplus bison slaughtered near Wainwright had tuberculous lesions (15). The herd was destroyed in 1940 and the park was officially disbanded in 1947.

Bovine tuberculosis was introduced into Wood Buffalo National Park between 1925 and 1928 when 6,673 plains bison were moved there by rail and barge from the infected herd at Buffalo National Park near Wainwright. From 1929 to 1974, bison were periodically slaughtered in Wood Buffalo National Park for meat production purposes. Lesions indicative of tuberculosis were first noted in the 1930's, and between 1952 and 1956, 39% of 1,508 bison had lesions (16). Intradermal tuberculin tests (caudal fold), using OT tuberculin, were used at five slaughters between 1955 and 1962 but reactor rates were notably lower than the prevalence of lesions in the bison. In the 1959–60 slaughter, Choquette *et al* (17) found 151 (13.5%) reactors among 1,116 bison tested. Reexamination of their data indicates that the intradermal OT tuberculin test only had a sensitivity of 66.6% but a specificity of 89.6%. Necropsy examinations indicated that 31 (14.2%) of 219 bison with tuberculous lesions had generalized tuberculosis and the remaining bison had caseous and/or mineralized lesions in one or more lymph nodes, especially those of the head and chest. Orchitis, metritis and fetal deaths were attributed to tuberculosis. A recently completed survey of bison in the Wood Buffalo National Park region found bovine tuberculosis in 15 (21%) of 72 bison (11).

Bovine tuberculosis has also occurred in zoo and ranched bison. Griffith (18) and Urbain (19–22) described fatal cases in British and French zoo collections during the 1930's and 1940's. Tuckermann (23) reported an outbreak of tuberculosis in 58 bison on the Trexler-Lehigh Game Preserve in Pennsylvania in 1955. The initial case was a bull that died of generalized tuberculosis; 11 of 13 tuberculin reactors in the herd had tuberculous lesions. Subsequently, affected bison often had rapidly progressing, fatal lesions and the herd was depopulated in 1960 (24). Bison at Golden Gate Park, San Francisco, contracted bovine tuberculosis in the 1950's and the small herd is being phased out by natural attrition. In 1977, Thoen *et al* (25) identified *M. bovis* isolates from three captive bison in the United States, and Fowler (26) found *M. bovis* in grossly normal mediastinal and mesenteric lymph nodes from one of eight bison during an epizootic at a zoo in California in 1978. In 1985, a privately-owned herd of approximately 155 bison in New Brunswick was depopulated because of bovine tuberculosis. Studies of bovine tuberculosis in bison indicate that the disease is similar to that in cattle (11,27).

The most significant outbreak of bovine tuberculosis in ranched bison was recognized in the United States in 1984 and 1985 (24,28,29). The disease was transmitted from captive elk (*Cervus elaphus*) (30) to two South Dakota bison herds between 1978 and 1982. Because the first case in a bison was not discovered until 1984, extensive trace-backs had to be done for bison sold

from the two primary-source bison herds. Of 115 bison herds tested in 24 states and one in Canada, 21 herds in 10 states were infected. Secondary trace-backs from these 21 infected herds required the examination of another 35 bison herds with negative results. The limited tuberculin testing, using purified protein derivative (PPD) tuberculin, during the outbreak suggested that the single comparative cervical test was highly sensitive and specific in bison; too few caudal fold tests were done to evaluate this method (29). The lesions in bison were usually restricted to the thoracic cavity and in nearly all instances were restricted to bronchial and/or mediastinal lymph nodes. As a result of the outbreak, 2,086 bison, 878 cattle, and 42 swine and goats were slaughtered.

A recent experimental study on the pathogenesis of bovine tuberculosis in a small sample of bison suggests that both the caudal fold and comparative cervical tuberculin tests, using PPD tuberculins, are effective in the diagnosis of the disease in bison (31). An enzyme-linked immunosorbent assay used in the experiment was also successful in differentiating infected and sensitized bison from control bison.

Anthrax (Bacillus anthracis). Williams (32) suggested that anthrax was brought to North America aboard ships during the 17th century. Stein (33) recorded an isolated outbreak in Kansas cattle in 1946 where old, eroded bison wallows were suggested as a source of anthrax spores. This implies that bison on the western plains contracted the disease. However, the first confirmed report of anthrax in bison did not appear until 1948. Three bison died in the Pittsburgh Zoo with clinical signs and/or necropsy findings indicative of anthrax (34). Anthrax bacilli were isolated from the enlarged spleen of one of these bison. The lesions reported were similar to those in cattle: serosanguineous fluid running from body openings and in body cavities; subcutaneous hemorrhages; severe pulmonary congestion; perirenal hemorrhages and blood in the renal pelves and ureters; splenomegaly with a dark, gelatinous appearance on cut surface.

In another incident, two men contracted anthrax while butchering an infected bison in New Mexico (35). Four other bison in that herd had died and *B. anthracis* was isolated from one of these.

Anthrax was first diagnosed in Canadian wildlife in 1962 when an outbreak occurred in free-ranging bison in the Northwest Territories (36–39). The original source of the disease in that area is not known. Between 1962 and 1978, sporadic epizootics of anthrax occurred in bison in the Slave River Lowlands and in Wood Buffalo National Park. During this period, summer surveillance teams found 1,100 dead bison. Confirmation by culture was not always possible and it is likely that some carcasses were not found. Carcasses were either limed and buried, or burned, buried, and the area limed. Two men involved in the disposal exercise contracted anthrax but responded to antibiotic therapy (40). An annual bison vaccination program was initiated in 1965 and cancelled in 1977. No anthrax losses have been reported in the region since 1978.

Hemorrhagic septicemia (Pasteurella multocida). This was the first contagious disease verified in bison. It killed 22 of 171 bison in Yellowstone National Park in December 1911 (41), and recurred in that herd in 1922 (42). In 1965, at the National Bison Range in Montana, three bison calves and a yearling died of hemorrhagic septicemia and seven calves and a yearling recovered from the disease following antibiotic therapy (43). The herd consisted of 480 bison at that time. The strains of *P. multocida* isolated from dead bison from Yellowstone in 1922 (strain M-1404) and from the National Bison Range in 1965 (strain P-1459), were biochemically and serologically similar. Annual vaccination of young bison at the National Bison Range began in 1966 using a bacterin of strain P-1459. A 1966-67 serosurvey detected significant antibody titers against *P. multocida* serotype 2 (Roberts type I, Carter type B) antigens (strain M-1404) in the bison herds at the National Bison Range, Custer State Park (South Dakota), Wichita Mountains Wildlife Refuge (Oklahoma), and Roosevelt National Park (North Dakota), but not in a privately owned herd in Nebraska (44). Bison at the National Bison Range were examined in 1972 and, although pasteurellae were not isolated from nasal cavities, antibodies to three strains of *P. multocida*, including type 2, were detected in many of the bison, regardless of vaccination status (45). Carter (46) noted that although hemorrhagic septicemia is enzootic in several U.S. bison herds, the disease has only occurred once in U.S. cattle (47). Experimental studies have shown that the M-1404 bison strain is highly pathogenic in domestic calves, pigs and mice (43).

Other bacterial diseases. Peterson and Roby (48) could not detect anaplasmosis (*Anaplasma marginale*) in 132 bison from an enzootic area in Oregon, and they failed to infect susceptible cattle by inoculating pooled bison blood. However, Zaugg and Kuttler (49) experimentally produced clinical anaplasmosis in both splenectomized and intact bison calves, and then experimentally transmitted the disease back to splenectomized cattle 61 and 71 days later. Infection was detectable hematologically and by card and complement fixation (CF) tests. The authors also screened 178 bison sera from the National Bison Range, Montana, and found one reactor on the card test and 28 positive and 40 suspect reactors on the CF test. Zaugg (50) further demonstrated that bison blood collected 314 and 496 days after experimental infection was still infective for splenectomized cattle. Infected bison maintained antibody titers for at least 15 months. Although bison were susceptible to *A. marginale*, Zaugg was unable to infect a splenectomized bison with *A. ovis* during ten months of repeated inoculations with infected sheep blood.

Other bacterial pathogens or diseases reported in bison include pneumonic pasteurellosis (51), actinobacillosis (17), *Erysipelothrix rhusiopathiae* (52), Johne's disease (53), and subcutaneous abscesses caused by *Actinomyces (Corynebacterium) pyogenes* (54). Public literature for bison ranchers also mentions pink eye, necrotic stomatitis, hoof rot, leptospirosis, and clostridial diseases (55,56). *Clostridium chauvoei* was isolated from tissues of one bison in Wood Buffalo National Park (park files, unpublished). One abortion

TABLE 1
Parasites reported in North American bison

Parasite	Location	Reference
A. Protozoa		
Eimeria auburnensis	intestine	68
E. bovis	intestine	68
E. brasiliensis	intestine	68
E. bukidnonensis	intestine	68
E. canadensis	intestine	68
Babesia major	erythrocytes	68
Sarcocystis bovicanis	muscle	70
S. cruzi	muscle	71
Sarcocystis sp.	muscle	72–76
Toxoplasma gondii	liver	77,78
Trypanosoma sp.	blood	79
B. Arthropods		
Cochliomyia macellaria	skin	80
Damalinia sedecimdecembrii	skin	73
Dermacentor andersoni	skin	73
D. nigrolineatus	skin	73
Hypoderma lineatum	skin, esophagus, spinal canal	73,81
Musca autumnalis	skin	82
Speliognathus australis	nasal sinus	73
C. Trematodes		
Fasciola hepatica	bile duct	73
Fascioloides magna	liver	73
Paramphistomum microbothrioides	rumen	83
D. Cestodes		
Echinococcus granulosus	liver	16,73
Moniezia benedeni	small intestine	71
M. expansa	small intestine	84
M. planissima (probably)[a]	small intestine	73
E. Nematodes		
Capillaria bovis	intestine	85
Chabertia ovina	cecum and colon	73
Cooperia bisonis[b]	small intestine	73
C. mcmasteri[c]	small intestine	73
C. oncophora	small intestine	73
C. surnabada	small intestine	73
Cooperia sp.	small intestine	73
Dictyocaulus filaria	bronchi	73
D. viviparus	bronchi	73
Dictyocaulus sp.	bronchi	73
Grosspiculagia lyrata[d]	small intestine	73
Haemonchus contortus	abomasum	73
Nematodirus filicollis	small intestine	86
N. helvetianus	small intestine	73
Oesophagostomum radiatum	colon	73
Oesophagostomum sp.	colon; intestinal nodules	73
Ostertagia bisonis	abomasum	73
O. ostertagi	abomasum	73
O. trifurcata	abomasum	73
Setaria labiatopapillosa	peritoneal cavity	73
S. yehi	peritoneal cavity	73
Setaria sp.	peritoneal cavity	73
Skrjabinagia bisonis	abomasum	86
Trichostrongylus axei	abomasum, small intestine	73
T. lerouxi	small intestine	73
Trichuris discolor	cecum	73
T. ovis	cecum	73

[a]Synonymous with *Moniezia benedeni* (86)
[b]Synonymous with *Cooperia oncophora* (86)
[c]Synonymous with *Cooperia surnabada* (87)
[d]Synonymous with *Skrjabinagia lyrata* (87)

due to *Listeria monocytogenes* occurred in a Saskatchewan bison herd in 1982 (Tessaro, unpublished). Rice (57) did not detect antibodies to Rocky Mountain spotted fever (*Rickettsia rickettsii*) or Q fever (*Coxiella burnetii*) in 36 bison from Alberta in the 1940's. There was no evidence of leptospirosis or

Q fever in bison in Wood Buffalo National Park based on surveys of 388 sera (58,59).

Viral diseases of bison

Three epizootics of malignant catarrhal fever (MCF) were reported in captive bison herds in South Dakota between 1973 and 1976 (60). Morbidity ranged from 3% to 54% and the case fatality rate was 100% in the herds described. The diseases produced ulcerative lesions in the alimentary tract, trachea and bronchi similar to those seen in infected cattle; widespread necrotizing vasculitis without thrombosis characterized the histological lesions. Two of the three herd histories implicated domestic sheep as a source of infection. Wallman and Thompson (61) reported a case of MCF in a bison in Iowa in 1982. Liggitt *et al* (62) were able to experimentally transmit MCF from an infected domestic calf to a 1.5-year-old bison cow via whole blood transfusion. Again, the lesions were similar to those observed in typical cases in cattle. Todd and Storz (63) isolated a herpesvirus from various organs of a bison that died of MCF and they subgrouped the isolate as a cytomegalovirus based on electron microscopy. In examining tissues from bison that died of MCF, Amborski *et al* (64) subsequently discovered a retrovirus that had antigenic cross-reactivity with bovine syncytial virus (BSV), but not with bovine leukemia or bovine maedi-like retroviruses. The health significance of this newly identified retrovirus of bison is not known.

Two bison developed clinical signs of foot-and-mouth disease during an outbreak of the disease at the Paris Zoological Gardens in 1938 (65). Antibodies to bluetongue virus have been detected in bison herds in the U.S. (66), and antibodies to parainfluenza-3 virus were found in all of 38 bison sera collected at the National Bison Range in Montana (45). Rice (67) did not detect antibodies to eastern or western equine encephalomyelitis virus in 36 bison sera from two national parks in Alberta during the 1940's.

Parasites of bison

Bison are host to a variety of parasites which also occur in a wide variety of other cloven-hoofed mammals, including domestic cattle and sheep (Table 1). Most reports of parasites in bison are based on small numbers of bison from single populations in the U.S. Therefore, the prevalence, geographical distribution and clinical significance of most of these parasites cannot be widely interpreted. Fatalities have been attributed to babesiosis (*Babasia major*) and ostertagiosis (*Ostertagia ostertagi*) in captive bison (69,73). Experimental studies have also shown that bison are susceptible to infection with *Babesia bigemina*, and develop clinical and hematological signs of babesiosis. The disease can be experimentally transmitted between bison and cattle via inoculation of whole blood (88). Game ranching literature has attributed poor rates of gain and clinical disease to gastrointestinal nematodes, lungworms and liver flukes when high stocking rates have led to high parasite loads in bison. Hence, herd health schemes for bison often include parasite control programs (55,56,89).

Miscellaneous pathological conditions

A variety of noninfectious diseases and lesions of uncertain etiology have been reported in bison. Neoplasms reported in bison include teratoma (dermoid cyst), lipoma (81), bile duct adenoma, hepatic adenocarcinoma (90), testicular carcinoma (91), thyroid adenoma (59), testicular lymphosarcoma (92), and renal adenoma (11). Congenital defects reports include a case of coelosomia (93), hydrocephalus (94), and atresia ani and rectovaginal fistula (95). Throlson (56) has mentioned a congenital defect in bison characterized by poor muscle mass in the hindquarters, thickened hocks, and a tucked-up, stiff gait. The condition, referred to as "rabbit leg", is suspected of being a result of inbreeding. Dental abnormalities have also been observed in bison (95). Aflatoxin-induced abortion was reported in a bison at a Mexican zoo (97), and urea poisoning was documented in free-ranging Alaskan bison (98). Arteriosclerosis (11,81), chronic gastroenteritis, fetal death, cystic ovaries, hydrosalpinx, hydrometra (99), traumatic carditis (100), interstitial nephritis (101), hepatic cirrhosis (102), myocarditis (103), renal calculi (12), and capture myopathy (104) are other conditions that have been mentioned in bison. Rewell and Ainsworth (105) noted the presence of *Aspergillus fumigatus* in the lungs of bison. Liver abscesses of undetermined etiology have also been seen (14).

At bison slaughters at Wood Buffalo National Park, a variety of lesions were observed (17,58,92,106–109). *Brucella abortus* or *M. bovis* were occasionally isolated from cases of metritis, fetal deaths, orchitis and arthritis but in other instances, bacteriology was not done or the results were negative. Lesions of uncertain etiology included peritonitis, pleuritis, pneumonia, "pyemia", visceral and subcutaneous abscesses, liver lesions (adhesions, abscesses, cirrhosis and telangiectasis), arteriosclerosis, renal calculi, thyroid lesions (adenoma, hypoplasia, goiter), hypovitaminosis A, rectal prolapse and serous atrophy. Reproductive tract abnormalities in nonpregnant bison cows included ovarian hypoplasia and atrophy, cystic ovaries, bursal adhesions, hydrosalpinx, hydrobursitis, and parovarian and uterine cysts.

Conclusions

Commercial production of bison is becoming a growing industry in North America, yet the body of published information on diseases and parasites is inadequate: most is limited to qualitative observations about minimally managed herds, and none of it provides useful clinical material on diagnosis, treatment or preventive medicine.

As a starting point, it was deemed useful to provide a list of diseases that have been reported to occur in bison. The next step is to have published information that can be applied to herd health programs for the bison industry. One of the best means of developing this body of knowledge is for veterinarians to publish reports of their work on bison. Because bison and cattle are physically similar in many respects, and because they share a variety of diseases and parasites, there may be a tendency to assume that information on

diagnostic tests, therapeutic regimens, and vaccine efficacy in cattle can be directly extrapolated to bison. This may not always be a valid assumption.

The reports of significant foreign and indigenous livestock diseases in bison illustrate the importance of including bison in animal health programs and legislation aimed at controlling diseases and safeguarding the livestock industry.

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