

1999

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Observations on animal and human health during the outbreak of *Mycobacterium bovis* in game farm wapiti in Alberta

P. Nick Nation, E. Anne Fanning, H. Bim Hopf, Terry L. Church

Abstract — This report describes and discusses the history, clinical, pathologic, epidemiologic, and human health aspects of an outbreak of *Mycobacterium bovis* infection in domestic wapiti in Alberta between 1990 and 1993, shortly after legislative changes allowing game farming. The extent and seriousness of the outbreak of *M. bovis* in wapiti in Alberta was not fully known at its onset. The clinical findings in the first recognized infected wapiti are presented and the postmortem records for the herd in which the animal resided are summarized. Epidemiologic findings from the subsequent field investigation are reviewed, the results of recognition and investigation of human exposure are updated, and recommendations for reduction of human exposure are presented.

Résumé — Observations sur la santé animale et humaine au cours d'une flambée de *Mycobacterium bovis* chez des wapiti d'élevage en Alberta. Ce rapport décrit et discute les aspects historiques, cliniques, pathologiques, épidémiologiques et relatifs à la santé humaine d'une flambée d'infection à *Mycobacterium bovis* chez des wapiti d'élevage en Alberta entre 1990 et 1993, peu après des changements législatifs permettant l'élevage du gibier. L'extension et la gravité de la flambée de *M. bovis* chez les wapiti en Alberta n'étaient pas complètement connues à son début. Les observations cliniques du premier wapiti reconnu contaminé sont présentées et les dossiers post mortem concernant le troupeau d'appartenance de l'animal sont résumés. Les données épidémiologiques de l'investigation subséquente réalisée sur place sont revues, les résultats de l'identification et de l'investigation de l'exposition humaine sont mis à jour et des recommandations sont présentées pour réduire l'exposition humaine.

(Traduit par docteur André Blouin)

Can Vet J 1999; 40: 113-117

Introduction

M*ycobacterium bovis* was common in cattle until the advent of test and slaughter programs for its control (1-3). In developed countries, it is an infrequently reported pathogen in humans (4), attributed most commonly to ingestion of unpasteurized milk (2,5-8). In recent reports, its occurrence in humans has been linked to animal contact (2,6). In Alberta, which had been free of bovine tuberculosis (TB) from 1986 (Petran S, personal communication), an outbreak of TB in wapiti, and one human infection was linked to game farming,

provoking an extensive investigation by agencies concerned with both animal and human health. We present an overview of the outbreak and make recommendations for reduction of human exposure. To prepare this report, information was compiled from the personal experiences of the authors and the records of a private veterinary practitioner, Agriculture and Agri-Food Canada (AAFC), and Alberta Agriculture, Food and Rural Development.

Background information

Wapiti (*Cervus elaphus*), also known as elk, are native to western North America. In Alberta, they were traditionally considered the sole property of the Crown, and under the provincial Wildlife Act prior to 1984, it was illegal to keep wapiti, other than for viewing purposes (9). A big game farm permit was required to keep wapiti, and it was only issued to zoos, wildlife parks, and similar facilities (9). In 1984, a new Wildlife Act, effective in 1987, allowed certain formerly prohibited native species (wapiti, moose, white-tailed deer, mule deer) to be kept for game farm, display farm, or zoo purposes (9). The new Act contained provisions for the harvest and sale of

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This special report has been peer reviewed.

antler velvet from animals held on game farms. Under the new Act, trapping of free ranging wapiti was not permitted; all stock for domestic purposes had to be imported from domestic stocks elsewhere. As recently as 1986, there were only 4 major domestic wapiti herds in Alberta: one private, one at the Kikino Métis settlement, one at the University of Alberta, and one National Park herd.

Rapid growth characterized the wapiti industry in Alberta in the late 1980s. Despite the ability of wapiti to thrive in captivity, there were not enough animals being produced in the province to meet the increasing demands, and in late 1986, importers turned to the United States. A number of entrepreneurs entered the game farm industry, and between 1986 and the fall of 1988, wapiti were imported into Alberta from game farms in the United States. Prices for wapiti started rising in 1986 and resulted in considerable trading among herds. A moratorium on imports was declared in September 1988 to prevent possible introduction of disease and the meningeal parasite, *Paraelaphostrongylus tenuis* (10).

As the domestic wapiti herds continued to expand during the period 1988 to 1989, it became apparent that the Fish and Wildlife Division of Alberta Forestry, Lands and Wildlife did not have sufficient personnel to supervise game farming in Alberta. Therefore, discussions were held with Alberta Agriculture to transfer responsibility for game farming from Forestry, Lands and Wildlife to Agriculture. In response, in August 1990, the Livestock Diversification Act was drafted. This legislation provided the authority for Alberta Agriculture to license and administer farms for raising captive ungulates (11). The Act was not proclaimed until August 1991, and the transition to Agriculture was not completed until October 1991.

Original case: Clinical and pathologic findings

In April 1990, a cow wapiti on a game farm in central Alberta was reported to have weight loss and a poor appetite. On April 19, 1990, a veterinary practitioner incised and drained a retropharyngeal abscess. A clinical diagnosis of actinomycosis was made, and the cow was treated with streptomycin, intramuscularly (IM). There was no response to the initial treatment. Two further efforts at surgical drainage and antimicrobial treatment with penicillin and intravenous (IV) sodium iodide were made between May 10 and July 18, with no response.

On July 18, 1990, because the mass was 12 cm in diameter and the pharynx was irreparably damaged, the animal was euthanized, and a field postmortem was performed by the veterinary practitioner. Extensive purulent retropharyngeal, cervical, and mesenteric lymphadenitis and pneumonia were noted (Hauer G, personal communication). Tissues were submitted to the Animal Health Laboratory of Alberta Agriculture in Edmonton for histological examination and microbiological culture. Histological examination revealed a diffuse pyogranulomatous inflammatory reaction with a mixture of neutrophils, macrophages, and giant cells. Special stains demonstrated acid-fast bacteria in the cytoplasm of

Table 1. Index herd: Gross postmortem findings in wapiti

Status	Number	GVL ^a	LNP ^b	NVL ^c
Nonreactor	62	1	4	57
Reactors	32	13	7	12
Not tested	24	0	6	18
TOTAL	118	14	17	87

^aGVL: grossly visible lesions, lungs and/or lymph nodes

^bLNP: grossly visible lesions confined to lymph nodes only

^cNVL: no grossly visible lesions

Table 2. Summary of epidemiologic investigation from September 1990 to July 1993 following the diagnosis of tuberculosis in a herd of wapiti

Total registered wapiti herds	109
Herds quarantined	69
Herds with reactors	32
Herds culture positive (depopulated)	16

macrophages and giant cells. Mycobacterial infection was diagnosed, and material for mycobacterial culture was forwarded to AAFC's Animal Diseases Research Institute (ADRI) in Nepean, Ontario. *Mycobacterium bovis* was recovered in September 1990 from lung samples. The herd from which this animal originated will be referred to as the index herd for the purposes of this report.

Epidemiology and pathology in the index herd

Bovine TB is a federally reportable disease (12). Provincial governments do not have a legislated role in the control of TB in animals, but traditionally they have actively supported AAFC's TB control programs. Upon confirmation of the diagnosis, a control program was initiated, according to the captive ungulate policy of AAFC (13). The latter governs the control of TB, brucellosis, and other reportable diseases in commercially ranched cervidae and bison. Under this policy, isolation of *M. bovis* from any animal in a herd results in depopulation of all susceptible and exposed animal species on the premises, and consequent disinfection of the premises.

A field investigation identified 31 reactors among the 109 wapiti that were tested out of the total 150 wapiti in the index herd. The midcervical intradermal test using 100 µL (0.1 mL) containing 0.1 mg purified protein derivative tuberculin (PPD) was employed (14). Trace-back procedures (13) suggested that the infection had been introduced by wapiti consignments from a large herd in Montana in 1988. The index herd had sold animals to 42 other herds (contact herds) in the province but none outside Alberta. The index herd was slaughtered on-farm. Also slaughtered were 4 cattle and a herd of domestic mule and white-tailed deer. The carcasses were removed to a rendering plant where a gross postmortem was performed. Gross lesions were found in many wapiti but not in any of the mule or white-tailed deer. Records of the gross findings on 118 animals are presented in Table 1. The wapiti carcasses were skinned at the rendering plant and their hides were sent to 2 tanning plants. Following

Table 3. Mantoux test results on humans in contact with game farm wapiti from January 1991 to December 1994

Worker category	Number listed	Number not done	Negative ^a tests			Total percent positive	Positive ^b tests				INH ^h Rec/Compl ⁱ > 3 mo
			Initial -ve ^c	Initial F/U ^d -ve	Final-ve > June 92		Previous	New ^e	Convertor ^f	% BCG ^g	
Abattoir	32	1	9	9 (1) ^k	6 (1)	21.6	4 (1)	3 (2)	0	16	0/0
Farmer	232	31	77	85	11 (1)	12.1	16 (7)	12 (4)	0	5	6/0
Inspector	37	2	4	10	7	37.8	6	6 (2)	2 (1)	8	6/2
Laboratory	66	2	25	26 (1)	1	18.2	2 (1)	8 (7)	2	14	7/5
Unknown	7	6	1	0	0	0	0	0	0	0	1/0
Other	26	0	10	14	0	7.7	0	2	0	0	1/0
Rendering	71	1	5	23	25	24	5 (1)	7 (3)	5	6	13/10
Tanner	41	3	10	4	0	58.5	8 (2)	16 (9)	0	27	21/15
Federal vet ^l	20	1	4	2	6	35	3 (1)	4 (1)	0	10	3/1
Private vet	34	1	13	13	1	17.6	1	5	0	0	4/2
TOTAL	566	48	158	186 (2)	57 (2)	117	45 (13)	63 (28)	9 (1)	8	62/35
		8.5%	27.9%	32.9%	10%	Mean 20.7	8%	11.1%	1.6%		

^aNegative Mantoux test = < 10 mm diameter reaction

^bPositive Mantoux test = ≥ 10 mm reaction

^cNegative

^dFollowup

^eNew positive = no testing or negative more than 2 years ago

^fConvertor = negative to positive within 2 years

^gBCG = Bacille Calmette-Guerin

^hIsoniazid (isonicotine hydrazine)

ⁱReceived

^jCompleted

^k() number in parentheses is individual's BCG history

^lVeterinarian

examination, the carcasses were ground up and rendered into meat, bone meal, and fat.

Following depopulation of the index herd, all animals that had gone into contact herds were also removed and slaughtered. The remaining animals in contact herds were tested by the midcervical intradermal test. Reactor animals discovered in contact herds were removed and slaughtered and the herds were quarantined pending culture results. Isolation of *M. bovis* from a contact herd resulted in herd depopulation and the institution of further trace-back procedures.

Consequent epidemiology

All 16 infected herds and reactor wapiti were slaughtered by July 1993, and there have been no *M. bovis* reactors or positive cultures in Alberta since 1993. A review of trace-back records of this outbreak reveals a distinct double level pattern of herd infection. There were 3 heavily infected primary herds, the index herd and 2 others, which were defined by high levels of infection characterized by numerous skin test reactors, many animals with postmortem lesions, and culture positive animals. Postmortem findings from one of these herds have been published previously (15). There were 12 secondary herds that were defined by low levels of infection, a few reactors, no gross lesions in most cases, and only 1 or 2 culture positive animals. Results of epidemiological findings are summarized in Table 2.

An investigation was initiated by authorities in the United States (16), following the diagnosis of *M. bovis* infection in Alberta. The herd in Montana that supplied a large number of animals to the index herd was confirmed to have TB reactors in 1991 (7). Subsequent investigation from 1991 to 1996 revealed that 31 captive cervid herds in the United States were infected with

M. bovis (7). In 1991, a cattle herd in the United States infected by tuberculous wapiti was detected (7).

Human involvement

In November 1990, Tuberculosis Services, Alberta Health, was advised by AAFC of the presence of *M. bovis* infection in wapiti (17). Tuberculin testing of the owner and family of the index herd, the attending veterinarian and his animal health technician, and a veterinary student was performed. Human skin testing is performed by introducing 5 tuberculin units (TU) of PPD into the dermis of the forearm and reading the area of induration (18). A reaction at 48 to 72 h of ≥ 10 mm is considered significant, except in recent contacts, HIV-infected individuals, or those with lung scars suggestive of TB, in which case ≥ 5 mm is considered significant (18). The attending veterinarian, his animal health technician, and the veterinary student were all reactors to the intradermal tuberculin skin (Mantoux) test. Thoracic radiographs of all these tested appeared normal, but the sputum of the veterinarian was positive on culture for *M. bovis* in January 1991.

As the extent of the problem in the wapiti became clearer from the investigation by AAFC and, because the veterinarian, his assistant, and the veterinary student were reactors, investigation of human contacts was expanded to include other occupational groups in direct contact with wapiti. The results of this investigation are summarized in Table 3.

Conversions from negative to positive reactions from the first to the second Mantoux test were noted among renderers (5 of 71), laboratory workers (2 of 66), and inspectors (2 of 37). It is possible that negative to positive conversions were overestimated, because the first tuberculin test may have sensitized some individuals who

then reacted on the second test, a phenomenon referred to as "boosting" (19). Initial 2-step testing, which might have eliminated this possible source of error, was not used because of the urgency of the situation. Under the assumption that conversion from negative to positive status by 9 individuals was an indication of *M. bovis* infection, isoniazid (INH) prophylaxis was offered to all Mantoux positive individuals (18). Only 35 Mantoux positive individuals who started the prophylactic treatment completed more than 3 mo of the recommended 12-month treatment.

Discussion

Epidemiologic procedures were greatly aided by a number of factors. Alberta Fish and Wildlife kept a registry of game farms, and individual animal identification with a registered tamper proof ear tag was required. All sales, animal movements, deaths, births, etc. had to be recorded and reported to the Alberta Fish and Wildlife Division, which maintained computerized records. Access to these records greatly aided the epidemiologic study of the outbreak. Had these detailed records not existed, tracing of potentially infected animals would have been very difficult.

Mycobacterium bovis had never been reported from wapiti native to Alberta, so how did *M. bovis* enter the domestic wapiti population? Prior to import from Montana, the index animal had twice tested negative by the single intradermal, caudal fold, tuberculin test, the standard TB test required by AAFC for importation of wapiti at the time. It became apparent, both in Alberta and other jurisdictions, that wapiti do not react sufficiently well to the caudal fold test to give clear positive reactions (3,20). In 1988, with implementation of the Captive Wild Ungulate Policy in Canada, the midcervical intradermal test replaced the caudal fold test as the officially recognized screening test for wapiti (13).

Why was the disease not immediately recognized? First, because the Canadian bovine TB eradication program has been so successful, Canada now has a generation of veterinarians and veterinary pathologists who have never seen a case of bovine TB, and there are few with any firsthand experience of the disease. Second, the low incidence of *M. bovis* in western Canada for the past 30 y had caused complacency about the disease. Third, the tuberculous lesions that were seen in the wapiti were abscesses that were similar in their gross appearance and in the nature of their exudate to those formed by such organisms as *Actinomyces pyogenes*, *Pasteurella multocida*, or a number of other bacteria. It was only when it became obvious that the abscess in the originally discovered animal was refractory to surgical and medical treatment that histological examination was performed and the true nature of the lesion became apparent.

Of human contacts, those at greatest risk were rendering plant workers and veterinarians and technicians treating or examining infected wapiti. It is assumed that an aerosol may be created by the coughing of diseased animals, examination of lesions, and cleanup activities after carcass disposal, thereby posing a threat to those nearby. The public health investigation revealed a

Table 4. Authors' recommendations to reduce aerosol exposure of rendering plant workers

1. Minimize aerosols
2. Area disinfection (phenols, minimum 15 min contact) prior to hosing with cold water
3. Protective clothing especially covering hands and arms, plus HEPA filter face masks
4. Minimum 6 changes of air per hour, flow through (unrecirculating)
5. Education of workers
6. Personal hygiene
7. Skin testing prior to employment/exposure with annual retesting or other physician supervised followup

number of procedures used in various aspects of veterinary care and the meat packing, rendering, and tanning industries that favored aerosol spread of *M. bovis*. Handling animals in a chute, especially indoors or in an enclosed area, creates an aerosol by increasing the respiration rate of the animals. Further, procedures such as TB testing, bleeding, and ear tagging involve working around the head of the animal, where there is the greatest potential for exposure to an aerosol. Indoor post-mortem, slaughter, rendering, and hide treatment areas use steam pressured hot water hosing for cleanup. A fine aerosol of warm water is created and aerosolization of *M. bovis* in the environment may be enhanced. The use of air driven or electric equipment, such as meat saws, and the subcutaneous air injection of carcasses to aid in hide removal for tanning also create significant aerosols. Movement of carcasses or parts thereof around slaughter and rendering facilities via slides and chutes also creates aerosols, as does grinding of carcasses or carcass parts in such facilities. The authors have made a number of suggestions to reduce the human exposure to *M. bovis* in such situations (Table 4).

Human contact with *M. bovis* in this outbreak was likely via aerosol. This observation is consistent with similar observations made elsewhere (4). It suggests that the generally held historical view that *M. bovis* infections are primarily acquired by the ingestion of infected unpasteurized milk may be outdated in those countries in which animal control programs have significantly reduced the number of cases and personal and food hygiene practices are widespread. In these countries, aerosol may now be the main route of exposure of humans to *M. bovis*.

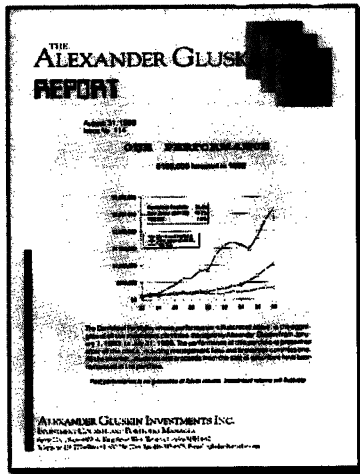
Acknowledgments

We thank Dr. G. Hauer for the use of clinical records, Dr. D. Undseth for postmortem records, and Dr. K. Orchard for field examination records. cvj

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