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Source: Journal of Wildlife Diseases, 26(4) : 453-459

Published By: Wildlife Disease Association

URL: https://doi.org/10.7589/0090-3558-26.4.453

*Journal of Wildlife Diseases*, 26(4), 1990, pp. 453–459


# SURVEY OF HEPATIC AND PULMONARY HELMINTHS OF WILD CERVIDS IN ALBERTA, CANADA

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ABSTRACT: During the 1988 hunting season, livers and lungs from 263 mule deer (*Odocoileus hemionus hemionus*), 198 moose (*Alces alces*), 147 white-tailed deer (*Odocoileus virginianus*), and 94 wapiti (*Cervus elaphus nelsoni*) from Alberta (Canada) were collected for parasitological examination. Most of the samples (89%) were submitted by big game hunters throughout the province. Giant liver fluke (*Fascioloides magna*) was found in 9% of 22 yearling and 29% of 65 adult wapiti; 4% of 161 adult moose; and 2% of 97 adult white-tailed deer. The intensity of infection generally was low; however, one wapiti had over 600 flukes in the liver. Infections were restricted to alpine and montane regions in southwestern Alberta (97%) as well as boreal uplands of the Cypress Hills in southeastern Alberta (3%). Other parasites recorded included *Taenia hydatigena* cysts in liver of 61% of 191 moose and 14% of 247 mule deer. *Dictyocaulus viviparus* was found in lungs of 14% of 50 moose, 14% of 118 mule deer, 12% of 41 wapiti, and 6% of 54 white-tailed deer. *Echinococcus granulosus* cysts were found in lungs (and occasionally liver) of 37% of 51 moose. Incidental infections of *Thysanosoma actinoides*, *Orthostrongylus macrotis*, and *Taenia omissa* were recorded. Adult *Dicrocoelium dendriticum* were collected from liver of two wapiti, one mule deer, and one white-tailed deer from the Cypress Hills.

*Key words:* Helminths, survey, wild ruminants, *Odocoileus hemionus hemionus*, *Alces alces*, *Odocoileus virginianus*, *Cervus elaphus nelsoni*, *Fascioloides magna*, *Dicrocoelium dendriticum*, lungs and liver infection.

## INTRODUCTION

*Fascioloides magna*, the giant liver fluke, is a well-known parasite of white-tailed deer (*Odocoileus virginianus*) in eastern North America (Erhardova-Kotrla, 1971; Foreyt, 1981). It also can infect a variety of wild and domestic species. Adult *A. magna* usually are found encapsulated in the liver, often in pairs, while immature parasites migrate throughout liver tissue apparently until they locate another individual. The parasite is relatively benign in white-tailed deer and caribou (*Rangifer tarandus*) populations but can cause extensive damage in some individuals. Direct and indirect mortality has been associated with infections in moose (*Alces alces*) (Olsen and Fenstermacher, 1942; Karns, 1972, 1973; Wobeser et al., 1985), wapiti (*Cervus elaphus nelsoni*), (M. J. Pybus, unpubl. data), and black-tailed deer (*Odocoileus hemionus columbianus*) (Hadwen, 1916; Cowan, 1946). In addition, *F. magna* can cause significant damage to liver and/or death of domestic species sympatric with infected wildlife (Foreyt, 1981).

Giant liver flukes have been found in Alberta in a variety of hosts from Buffalo National Park at Wainwright (Cameron, 1923; Swales, 1935), Banff National Park (Flook and Stenton, 1969), and the Waterton area of southwestern Alberta (Flook and Stenton, 1969; Kingscote et al., 1987).

A recent survey (1984 to 1989) in Banff National Park and Kootenay National Park (M. J. Pybus and J. G. Woods, unpubl.) indicated high prevalence of *F. magna* in adult wapiti (86% of 149 adults examined), moose (85% of 13) and white-tailed deer (60% of 15). A few infected mule deer, (*Odocoileus hemionus hemionus*), also were recorded (14% of 22). The data indicated a recent movement and establishment of the parasite in the lower Bow valley and infections in wapiti and moose often were accompanied by extensive damage to liver tissue.

*Fascioloides magna* readily expands its range by natural dispersal or artificial

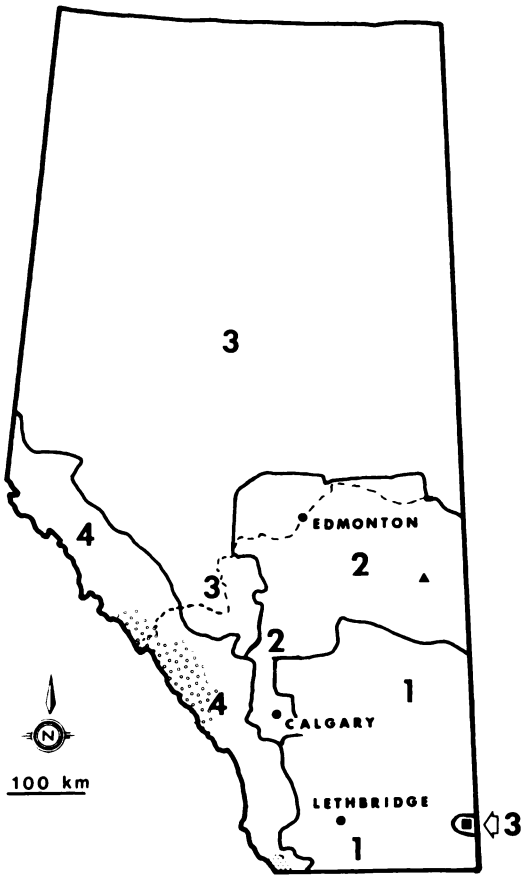


FIGURE 1. Major habitat types of Alberta (modified to accomodate Wildlife Management Unit boundaries): 1, Grasslands; 2, Aspen Parkland; 3, Boreal Uplands and Northern Mixedwoods; 4, East Slopes and Foothills; ▲ Camp Wainwright; ■ Cypress Hills; ⚿ Banff National Park; ⊞ Waterton National Park; - - - North Saskatchewan River.

translocation with infected hosts into new areas. The first report of *F. magna* followed introduction of the parasite into Italy with infected wapiti from western North America (Bassi, 1875). In order to avoid similar spread of the parasite due to management practices of translocation of free-ranging animals and movement of game farm animals, it is necessary to know where and in what hosts the *F. magna* already exists. Thus, the objective of the current survey was to provide information about the present geographic and host distribution of *F. magna* throughout Alberta. Other parasites were observed as noted.

TABLE 1. Source of wild cervids examined for helminths in Alberta, Canada.

| Species | Cause of death | | | | Total |
|---|---|---|---|---|---|
| | Hunter | Native | Motor vehicle | Other | |
| Wapiti | 66 | 7 | 15 | 6 | 94 |
| Moose | 190 | 1 | 4 | 3 | 198 |
| Mule deer | 237 | 4 | 11 | 11 | 263 |
| White-tailed deer | 116 | 1 | 27 | 3 | 147 |
| Total | 609 | 13 | 57 | 23 | 702 |

## MATERIALS AND METHODS

Collection of samples relied heavily on cooperation of big game hunters throughout Alberta. A variety of methods was used to notify hunters about the survey. These included direct contact with sportsmen's groups, articles and/or notices in sporting magazines, notices mailed to many applicants successful in management draws, notices displayed in offices of the Alberta Fish and Wildlife Division during the 1988 hunting season, and a press release circulated to weekly and daily newspapers throughout Alberta. In addition, Saskatchewan hunters in the Cypress Hills area (49°30'N, 109°50' to 110°30'W) were requested to submit samples for the survey. Native hunters were notified of the survey at various Band Council meetings and asked to submit samples throughout 1988. Field staff of the Alberta Fish and Wildlife Division were requested to collect samples whenever the opportunity arose.

All persons collecting samples were requested to provide the date, location, species, sex, and age (juvenile or adult) of the animal. Most samples were frozen; however, samples from Camp Wainwright (52°45'N, 111°0'W) were examined fresh.

Incomplete samples or those lacking location of the kill were not examined. Remaining livers were thawed, sliced thinly (5 mm), and all parasites and/or lesions noted. Intact lungs were examined grossly and the air passages opened with scissors.

The location of each sample, by Wildlife Management Unit (WMU), was assigned to one of eight major ecoregions (Strong and Leggat, 1981). The ecoregions were grouped into four habitat types; these were aspen parkland, boreal uplands and northern mixedwoods, east slopes and foothills, and grasslands (Fig. 1).

A subsample of parasites collected was fixed, cleared and identified using standard methods and reference keys. Representative samples were deposited in the National Museum of Natural

TABLE 2. Distribution of samples examined for liver and lung helminths in four major habitat types of Alberta, Canada.

| Habitat type | Wapiti | Moose | Mule deer | White-tailed deer | Total |
|---|---|---|---|---|---|
| Aspen parkland | 2 | 2 | 70 | 81 | 155 |
| Boreal uplands and mixedwoods | 32 | 116 | 50 | 13 | 211 |
| East slopes and foothills | 41 | 80 | 31 | 18 | 170 |
| Grasslands | 19 | 0 | 112 | 35 | 166 |

Sciences (Division of Invertebrate Zoology, Ottawa, Ontario, Canada K1A 0M8; Accession number NMCP1989-0537 to NMCP1989-0550).

## RESULTS

Liver and often lungs from 702 animals were examined. Most were from hosts killed by big game hunters (89%) in October to December 1988. Samples from 198 moose, 263 mule deer, 147 white-tailed deer and 94 wapiti (Table 1) were collected widely throughout the province. Many livers were collected in Cypress Hills ($n$ = 135) and Camp Wainwright ($n$ = 80) (Fig. 1), but overall, samples were well-distributed among the habitat types (Table 2).

*Fascioloides magna* was found in the liver of 29 animals (Table 3). Prevalence was similar in males and females; however, intensity was higher in male than female wapiti. One heavily infected adult male wapiti (608 *F. magna*) was not included in the comparison.

All but one infection of *F. magna* were recorded from alpine or montane ecoregions in the east slopes and foothills of southwestern Alberta (Table 4). Liver flukes were recovered from 18 (67%) of 27 adult wapiti and seven of ten WMUs from which wapiti were collected in this habitat. One infected wapiti was collected in the Cypress Hills.

Several other parasites were collected during this survey (Table 4). These included *Taenia hydatigena* cysts in liver of 117 (61%) moose, 34 (14%) mule deer, seven (5%) white-tailed deer, and two (2%) wapiti; *Dictyocaulus viviparus* in lungs of seven (14%) moose, 17 (14%) mule deer, five (12%) wapiti, and three (6%) white-tailed deer; *Echinococcus granulosus* cysts in lungs (and occasionally liver) of 37 (73%) moose and six (21%) wapiti; and *Thysanosoma actinoides* in liver of eight (4%) moose, three (3%) wapiti, and one (0.4%) mule deer. In addition, *Orthostrongylus macrotis* and *Taenia omissa* were found in lungs of eight (3%) mule deer and two (0.8%) mule deer, respectively.

*Dicrocoelium dendriticum* was found in hepatic ducts of two wapiti, one white-tailed deer, and one mule deer from Cypress Hills. In three cases intensity was low

TABLE 3. *Fascioloides magna* in samples of wild cervids collected from Alberta, Canada surveyed during Fall 1988.

| Species | Number examined[a] | | | | Prevalence (%) | | | Intensity | |
|---|---|---|---|---|---|---|---|---|---|
| | Total | YOY | YLG | Adult | YOY | YLG | Adult | YLG | Adult[b] |
| Wapiti | 94 | 7 | 22 | 65 | 0 | 9.1 | 29.2 | 1, 36 | 25 (33), 1–115[c] |
| Moose | 191 | 9 | 21 | 161 | 0 | 0 | 3.8 | — | 3 (1), 2–5 |
| Mule deer | 247 | 13 | 71 | 163 | 0 | 0 | 0 | — | — — |
| White-tailed deer | 140 | 20 | 23 | 97 | 0 | 0 | 2.1 | — | — 3, 31 |

[a] Unaged animals not included; YOY, young-of-the-year; YLG, yearling.
[b] Mean number of *F. magna* (SD), range.
[c] Does not include one wapiti with 608 flukes.

TABLE 4. Distribution of helminths from wild cervids in four major habitat types of Alberta, Canada.

| | *Dictyocaulus viviparus* | *Echinococcus granulosus* | *Fascioloides magna* | *Taenia hydatigena* | *Thysanosoma actinoides* |
|---|---|---|---|---|---|
| Number of infected animals | 32 | 25 | 29 | 162 | 12 |
| Aspen parkland | 7 (22)* | 0 | 0 | 13 (8) | 0 |
| Boreal uplands and mixedwoods | 13 (41) | 14 (56) | 1 (3) | 87 (54) | 4 (33) |
| East slopes and foothills | 7 (22) | 11 (44) | 28 (97) | 50 (31) | 8 (67) |
| Grasslands | 5 (15) | 0 | 0 | 12 (7) | 0 |

* Number of cases in habitat type (% of total cases of each parasite).

(three and 11 trematodes collected from wapiti and 11 from the white-tailed deer). However, an infection of at least 174 *D. dendriticum* in the mule deer was associated with enlargement of all major hepatic ducts and extensive accumulation of thick yellow/brown exudate in the biliary system throughout the liver.

## DISCUSSION

Of the parasites collected during this survey, *F. magna* is of greatest concern to wildlife managers. It is common in wapiti in the foothills and mountains of southern Alberta and also occurs in moose and white-tailed deer sympatric with infected wapiti. Despite extensive examination of wapiti livers by hunters, there are no previous records of *F. magna* occurring in the central mountains and foothills of Alberta outside of Banff National Park. However, our results indicate the parasite also is present in ungulate populations adjacent to the park. This may be the result of a recent movement of this parasite with infected wapiti from the Banff area. The distribution of *F. magna* coincides with natural dispersal and migration patterns of wapiti within the region (Morgantini and Hudson, 1988; Woods, 1988) and supports other reports that *F. magna* readily moves with its hosts into new areas.

In the extreme southwestern part of Alberta, giant liver fluke has been reported in Waterton Lakes National Park (Flook and Stenton, 1969) and was found in 63% of 16 adult wapiti killed by hunters in the Waterton area in 1984 (Kingscote et al., 1987). It probably is present throughout the upland areas of southwestern Alberta.

This is the first confirmed report of *F. magna* in the Cypress Hills of southeastern Alberta and southwestern Saskatchewan. Wobeser et al. (1985) reported operculate trematode eggs in 10 of 50 fecal samples from wapiti in the Saskatchewan Cypress Hills but were unable to determine their identity. The eggs were smaller than most eggs of *F. magna* and livers were not available for examination. In addition, Samuel et al. (1976) did not find liver flukes in 23 moose from the Alberta Cypress Hills. The area is an isolated region of boreal upland habitat surrounded by prairie grasslands. It appears that *F. magna* is present at very low levels in this area and is unlikely to have significant impact on moose or wapiti in the Cypress Hills.

It is significant that *F. magna* was not found in deer collected from Camp Wainwright in east central Alberta. In 1923, "several" bison (*Bison bison*) livers from Buffalo National Park (which later became Camp Wainwright) contained giant liver fluke (Cameron, 1923). Reports filed by Parks Canada personnel in 1931 and 1932 indicated the number of infected ruminants in the park was increasing. By 1933 many wapiti and deer were "heavily" infected with *F. magna* (Swales, 1935) and the parasite was a major problem for wildlife managers.

Measures to eradicate giant liver fluke from Buffalo park were undertaken in the late 1930's. Selected swamps and lakes were treated with copper sulphate to destroy snail populations (Swales, 1935). In addi-

tion, over 5,000 cervids, mainly wapiti, and bison in the park were slaughtered to try to control various disease problems, particularly brucellosis and tuberculosis (Lothian, 1981). *Fascioloides magna* was not observed during cursory examination of large numbers of livers of hunter-killed white-tailed deer and mule deer from Camp Wainwright between 1966 and 1987 (Wishart, pers. comm.) nor in 40 white-tailed deer and 40 mule deer examined during the current survey. It is apparent that the drastic methods of the 1930s were successful in eradicating *F. magna* from the area. However, considering the great environmental impact of such methods, they are unlikely to be used in a modern situation.

The high intensity of *F. magna* in some wapiti indicates good potential for releasing large numbers of eggs into the environment, thus promoting further spread of the parasite in suitable areas. In order for the giant liver fluke to complete its life cycle, such areas must include permanent or temporary waterbodies with abundant snail populations and submerged or emergent vegetation.

Diagnostic tests for *F. magna* involving examination of fecal samples for eggs (Foreyt, 1981; Wobeser et al., 1985) can be used to identify most infected individuals. Until a successful anthelminthic against *F. magna* in wapiti is identified, infected wapiti from areas in Alberta south of the North Saskatchewan River should not be translocated to areas with conditions suitable for transmission of liver flukes. Similarly, infected wapiti from areas outside Alberta should not be moved into parts of the province currently free of the parasite. Wildlife managers in other areas should consider the potential hazards associated with giant liver fluke before translocating wapiti or white-tailed deer.

Results pertaining to parasites other than *F. magna* generally update the information of Samuel et al. (1976), Flook and Stenton (1969), Stock and Barrett (1983), and Kingscote et al. (1987). However, our samples were collected over a much wider geographic area and provide information concerning more general patterns of host and geographic distribution. *Dictyocaulus viviparus* was the most ubiquitous parasite and was found throughout the range of hosts and habitats examined. As in other reports, these lung nematodes were more common in yearling and young-of-the-year animals.

Larvae of *T. hydatigena* and *E. granulosus* were most often found in moose, particularly in the Swan Hills area of northern Alberta. Similar high prevalence of these larval tapeworms in moose in the Swan Hills was reported by Samuel et al. (1976). Fuller and Keith (1980) reported high wolf (*Canis lupus*) populations in the area in the late 1970's. Since wolves are definitive hosts for both parasites, the data probably reflect continued high populations of wolves in northcentral Alberta. Similarly, in southwestern Quebec, high levels of hydatid cysts in moose have been correlated with high densities of wolves (Messier et al., 1989).

*Echinococcus granulosus* infections were restricted to upland and northern mixedwoods habitats and were not found in mule deer or white-tailed deer. Since all four host species are sympatric in these habitats, our results suggest the life cycle of hydatid tapeworm in these areas is dependent upon moose and/or wapiti as suitable intermediate hosts. Heavily infected moose and wapiti often had hydatid cysts in liver as well as lungs.

The apparent low prevalence of *T. actinoides* in this study probably underestimates its presence in host populations. This tapeworm normally occurs in the biliary system of the liver of infected hosts. However, it moves rapidly into the small intestine after death of the host and usually is recorded in the duodenum or abomasum (Allen, 1973; Stock and Barrett, 1983). The high proportion of infected livers in animals from the upland habitats suggests the parasite is abundant in southwestern Alberta and the Cypress Hills. Similar high

prevalence has been reported in moose (Samuel et al., 1976; Stock and Barrett, 1983) and wapiti (Stock and Barrett, 1983) from the Cypress Hills.

Adult *D. dendriticum* have not been reported previously from cervids in Canada. This fluke commonly is found in domestic sheep and cattle and a variety of wild ruminants throughout Europe. It is distributed widely in domestic species in North America; however, reports from wild cervids are limited (Mapes and Baker, 1950; Schulte et al., 1976). The only previous record of *D. dendriticum* from western Canada is from cattle in British Columbia (Lewis, 1974). The parasite is small and inconspicuous and easily could be overlooked during routine necropsies. Its presence in wapiti and deer in the Cypress Hills suggests local abundance in domestic species with sympatric use of contaminated range.

## ACKNOWLEDGMENTS

The success of this survey primarily resulted from the enthusiastic cooperation of over 800 hunters who submitted liver and lung samples for examination. In addition, the office and field staff of the Alberta Fish and Wildlife Division also were instrumental in receiving and transporting survey material. One and all are gratefully acknowledged. Lyle Fullerton (Alberta Fish and Game Association), Sylvia Schurman and Ken Crutchfield (Alberta Fish and Wildlife Division), and Dwight Dobson (Saskatchewan Parks and Renewable Resources) assisted in distributing survey notices and media information. Dwight Dobson also collected samples from hunters in the Saskatchewan Cypress Hills. Financial support for this program was provided by the Alberta Recreation, Parks and Wildlife Foundation. Logistical support was provided by the Alberta Fish and Wildlife Division.

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*Received for publication 26 June 1989.*