The Sixth North American Caribou Workshop,
Prince George, British Columbia, Canada,
1-4 March, 1994.

Prevalence of *Echinococcus granulosus* and *Taenia hydatigena* in caribou in north-central Canada

Donald C. Thomas

Canadian Wildlife Service, Environment Canada, 4999-98 Ave., #200, Edmonton, Ab. T6B 2X3.

Abstract: There are few data on the prevalence and infection intensity of parasites in large samples of caribou (*Rangifer tarandus*). Therefore, differences related to sex, age, and season are unknown. The effect of parasites on the health and condition of caribou also is poorly known. From 1980 through 1987, 1258 barren-ground caribou (*R.t. groenlandicus*) were collected from the Beverly herd in north-central Canada. The prevalence in lungs of cysts of the hydatid tapeworm (*Echinococcus granulosus*) increased significantly with age of caribou. Prevalence in females was 2% in the 2-5 year class and 8% in older individuals. Cysts were more prevalent in young females compared with young males. Reductions in physical condition and fecundity were not statistically significant. The prevalence of *Taenia hydatigena* cysts in livers increased significantly with age of host but not with sex and condition of the hosts. The use of parasite prevalence as an index of predation rate is discussed.

Key words: caribou, *Rangifer tarandus*, parasites, *Echinococcus granulosus*, *Taenia hydatigena*

Rangifer, Special Issue No. 9, 331-336

Introduction

Most information on the prevalence and intensity (number and size of cysts/animal) of internal parasites of barren-ground caribou is based on small sample sizes and is not specific to sex, age, season, or condition of the hosts. Furthermore, the debilitating effect of these parasites, if any, is virtually unknown. Are they a hmiting factor by lowering fecundity or increasing mortality? Some significant negative relationships occurred between the intensity of warble (*Oedemagena tarandi*) larvae and condition indices of caribou (reviewed by Huot & Beaulieu, 1985; Thomas & Kiliaan, 1990). Fecundity is inextricably linked to condition in caribou (e.g., Thomas, 1982). Therefore, any debilitating effect of parasites could reduce condition and, in turn, reduce fecundity. Mortality rate also is linked to condition.

The purpose of this paper is to report the prevalence and intensity of larval stages of *Echinococcus granulosus* and *Taenia hydatigena* in relation to sex, age, pregnancy rate, and physical condition of caribou, an intermediate host for these tapeworms. Additionally, I speculate on use of these parasites as indices of predation.

Data in this paper came from samples of migratory barren-ground caribou of the Beverly herd obtained in December and March. The Beverly herd uses forested winter range in northwestern Manitoba, northern Saskatchewan, and the Northwest Territories as far west as central Great Slave Lake. Information on parasites were obtained incidental to primary objectives related to evaluating effects of forest fires on caribou and their winter range. More details are in an unpublished report (Thomas & Kiliaan, 1994).

Methods

In cooperation with the Fort Smith Hunters and Trappers Association, 1258 caribou were collected from 1980 through 1987. Prior to 1985, there was no systematic search of lungs and livers for cysts. Some small hydatid cysts may have been overlooked by the hunters who were asked to report anything unusual about caribou while skinning and evicerating them. Beginning in March 1985, I visually inspected the lungs of all caribou and palpated them for internal hydatid cysts. The diameters of cysts were measured with a ruler. I also checked the surface of the liver for larvae and sections 3 mm apart enabled examination of most of the liver tissue.

Whole body weights were obtained with a dial scale and tripod. Depth of back fat was measured at its maximum thickness along a cut anterio-lateral to the base of the tail. Weights were obtained for the kidneys and for surrounding fat trimmed flush with

Table 1 Prevalence of lung and liver cysts in caribou sampled from the Beverly herd from March 1985 - 1987.

Month/ Year	*Echinococcus granulosus* Sample size	Caribou w/ cysts	Prevalence (percent)	*Taenia hydatigena* Sample size	Caribou w/ Cysts	Prevalence (percent)
Mar 85	162	8	4.9	162	25	15
Dec 85	78	2	2.6	77	23	30
Mar 86	150	7	4.7	149	32	21
Dec 86	49	1	2.0	49	11	22
Mar 87	49	1	2.0	40	9	23
Totals: Dec	127	3	2.4	126	34	27[a]
Totals: Mar	361	16	4.4	351	66	19[a]
Totals/ave.	488	19	3.9	477	100	21[a]

[a] Samples from all age classes and from December and March should not be pooled but the data are presented to facilitate comparisons with results for herds where age and season were not partitioned.

the ends of each kidney. A first incisor and first molar were used for age determination. Age was rounded to the next birthday; e.g., 5.5 became 6 years.

Data for all years were pooled for sex and age classes for comparisons with other pooled data even where grouping was not justified statistically. The significance of differences were tested with χ^2 where α was 0.05.

Results

Echinococcus granulosus

The range in prevalence was 2.0%-4.9% in five samples obtained from 1985 through 1987 (Table 1) (X^2=1.8, p>0.8). The age distribution of infected females differed from their age structure in the sampled population (Thomas & Barry 1990) but not when calves were excluded (X^2=14.8, p=0.11). Number of infected females in the 2-5 year and >5 year classes differed from that expected by the age structure (X^2=36, p<0.001). In females >1 year of age, a correlation of prevalence with age was significant (Spearman r=0.96, p<0.01). A plot of cumulative cyst volumes with age was not significant but average diameter of cysts was correlated with age (Spearman r=0.66, p<0.01). No cysts >4 cm in diameter occurred before age 6 years.

There were more infected females than expected from the 2 female:1 male ratio in the sampled population (X^2=4.7, p<0.05). The higher prevalence in female caribou was confined to the 3-5 year class (Table 2). The prevalence in caribou >5 years old was 8.3% in both sexes.

There were no statistical differences in prevalence for season (December vs. March) or for years (1985 vs. 1986 vs. 1987). Therefore, the data were pooled.

Data on parasite intensity and condition indices of 10 caribou with the most intense infections are presented in Table 3. The only caribou with a massive hydatid infection was considerably leaner than average for its age class (Table 3). An analysis of individuals whose condition indices were outside the confidence limits (CL) revealed the following: for weight, 5 lower than the CL and 9 higher; for depth of back fat, 11 lower and 7 higher; and for weight of kidney fat, 10 lower and 5 higher.

The prevalence of *E. granulosus* in females 2-5 years old did not differ between individuals with less than and greater than median back fat: 2% in each case (n=182). Nor was the difference significant in females >5 years old (prevalence 8% vs. 12%; n=172; p=0.4).

The pregnancy rate of infected individuals was 72% (n=18); that of non-infected females was 84% (X^2=0.9, n=279, p=0.33). However, only 1 of 10 females that were most-intensely parasitized was not pregnant (Table 3).

Table 2: Prevalence of *Echinococcus granulosus* in the lungs of caribou by sex and age classes, 1985 through 1987.

Age class (years)	Females Sample size	Females Prevalence (percent)	Males Sample size	Males Prevalence (percent)	Both sexes[a] Sample size	Both sexes[a] Prevalence (percent)
1[b]	10	0	6	0	16	0
2	26	0	27	0	53	0
3	57	2	53	0	110	2
4	59	3	19	0	78	1
5	40	3	16	0	56	2
6-11	143	8	12	8	155	8
>11	26	8	0	0	26	8

[a] Data pooled for comparisons with data from other studies.

[b] Cysts take several months to develop and therefore seldom appear in calves.

Table 3. Condition indices of the 10 caribou most intensively infected with *Echinococcus granulosus* and average condition indices for their sex and age class.

Sex	Age (Yr)	Preg?	No. of cysts	Ave. dia (cm)	Cyst vol. (cm^2)	Fatness: individual vs. average					
						Back fat (mm)			Kidney fat(g)		
						Indiv.	Ave[b]	CC[c]	Indiv.	Ave[b]	CC[c]
F	10	Y	6	2	11	5	12.2	2.7	102	101	12
F	9	Y	2	3	12	18	12.2	2.7	138	101	12
F	4	Y	1	4	13	22	18.9	4.8	84	64	23
M	7	Y	1	5	20	0	1.0	12.7	62	73	>99
F	14	Y	2	5	39	18	20.8	11.5	132	76	39
F	8	Y	1	7	39	40	18.4	2.7	131	123	11
F	6	Y	1	8	44	9	12.2	2.7	101	101	12
F	10	N	3	6	85	2	15.0	4.5	46	91	16
F	6	Y	7	4	88	11	4.6	3.3	125	65	15
F	6	Y	12	5	235	12	19.7	2.9	37	124	11

[a] Volume in cm^2.

[b] Average for age class.

[c] CC is basis for calculating the approximate confidence limit (CL) where CL = mean ± CC and CC = $SE \times t_{.05}$ for N-1 samples (2 tail).

Taenia hydatigena

There was no difference in prevalence between males and female caribou even where age and season were taken into account. Data for prevalence were homogenous within the 2-6 and >6 year groups. Prevalence declined 30% and 25% from December to March in 2-6 year old and >6 year old caribou, respectively. These data are for females in 1985/86 and 1986/87, respectively, where sample sizes were largest. There was no change from December to March in 1986/87 when both sexes and all ages were combined (Table 1).

There was an age difference in prevalence in December samples: 0% (n=4), 23% (n=89) and 40% (n=30) in 1, 2-6, and >6 year old caribou respectively (X^2=42, p<0.001). The same trend, with lowered prevalence, continued in those age classes in March samples: 0% (n=12), 16% (n=257), and 30% (n=82) (X^2=30, p<0.001).

Prevalence of *T. hydatigena* in March samples was similar in pregnant females (PF) and non-pregnant females (NPF) >2 years old: in December samples, 31% in PF (n=59) vs. 26% in NPF (n=19); in March samples, 20% in PF (n=196) vs. 16% in NPF (n=31). Prevalence of cysts in March samples was also similar in females with greater than (>) and less than (<) median depth of back fat: in females 2-5 years old, both 14% (n=65, 64); in females >5 years old, 27% (>) vs. 23% (<) (n=59,61).

Discussion

Are E. granulosis *and* T. hydatigena *debilitating?*

These data are inconclusive for the hydatid tapeworm. The only caribou with a massive infection was relatively thin. If caribou with massive infections fall prey to wolves, there is little chance of sampling them. Massive infections of large hydatid cysts may make caribou more vulnerable to wolf predation where chases are long. However, light and moderate infections do not reduce condition and fecundity significantly. There was no indication that *T. hydatigena* was debilitating.

Parasite prevalence and intensity as an index of predation?

Information on the effect of predators on wild populations is exceedingly difficult to obtain. Because *E. granulosus* and *T. hydatigena* have obligate, definitive, canid hosts for the adult tapeworm, the incidence of these species in caribou may provide an index to predation rate. They may cycle primarily through wolves (*Canis lupus*) as opposed to coyotes (*C. latrans*) and foxes (*Vulpes vulpes*; *Alopex lagopus*) (Holmes & Podesta, 1968; Addison *et al.*, 1988). The prevalence of *E. granulosus* in caribou was 6.3% in the Qamanirjuaq herd (Broughton & Choquette, 1969); 3.9% in this study (Table 1); and 1.3% in the George River herd (Parker, 1981). Wolf abundance was subjectively rated as relatively high (Parker, pers. comm.), relatively low-moderate (Thomas, unpubl. data), and relatively low (Messier *et al.*, 1988; Parker, pers. comm.) in the relevant periods in the three herds.

The prevalence, mean number, and mean total weight of *E. granulosus* in moose in Quebec was related to moose density and in turn to wolf predation rate (Messier *et al.*, 1989). Pybus (1990) infer-

red a relationship between the prevalence of hydatid cysts in moose and wolf densities in Alberta. The required large number of caribou samples and accurate surveys of wolf numbers and predation rate are not available for any caribou-wolf system.

The prevalence of *T. hydatigena* in caribou also fits subjective evaluations of wolf abundance. Cysts occurred in 25% of 809 caribou sampled in 1966-68 in the Qamanirjuaq herd (Broughton & Choquette, 1969) and in 17% (n=159) and 43% (n=30) of caribou in the George River herd in April 1981 and 1984, respectively (Parker, 1981; Huot & Beaulieu, 1985). Except for the 43% in the small sample in 1984, prevalence fits subjective evaluations of relative wolf abundance among those caribou populations. Adult *T. hydatigena* occurred in 27-80% of wolves (Holmes & Podesta, 1968; Samuel *et al.*, 1978).

There are problems with using parasite prevalence as an indicator of predation rate in hunted populations. Biases may result from infections obtained from viscera left by hunters and wounded animals that die, fall prey to wolves, or are scavenged by wolves.

Age and sex differences

Data for parasite prevalence and intensity should be presented specific to age and sex classes. Comparisons with grouped data for other populations may be invalid unless age and sex structures are similar and sample sizes are adequate. Changes with age and sex may reflect lags between infection and expression of the larval stage; different distributions of age and sex classes relative to sites of exposure; behavioral (e.g., foraging) differences that affect ingestion of eggs; and acquired resistance to the parasite.

Whereas the prevalence of *E. granulosus* and *T. hydatigena* tended to increase with age, the prevalence of *Parelaphostrongylus andersoni* in caribou of the Beverly herd declined progressively with age (Lankester & Hauta, 1989). Also, *T. hydatigena* was more prevalent in yearling white-tailed deer (*Odocoileus virginianus*) compared with fawns and deer >2 years old, although intensity tended to increase with age (Addison *et al.*, 1988).

The intensity of warble (*Oedemagena tarandi*) larvae declined with age in female caribou in the Beverly herd (Thomas & Kiliaan, 1990) and in the George River herd (Parker, 1981). Acquired resistance was one of several possibilities (Thomas & Kiliaan, 1990).

Season and year differences

Little seasonal or annual variation in prevalence should occur for hydatid cysts that develop slowly and persist for years. The low infection prevalences also largely preclude statistically significant differences. In contrast, the decline of 25-30% from December to March in the prevalence of *T. hydatigena* may indicate annual infection in summer and constant resorption. The higher prevalence and lower seasonal decline in prevalence in caribou over 6 years old may implicate slower resorption.

Management implications

Forest exploitation in the boreal and cordilleran forests may increase the prevalence of *E. granulosus* in caribou. The parasite could become more prevalent with extensive forestry that produces more early-succession stages and greater densities of moose, wapiti, deer, and wolves. Whether such increases reduce the fitness of caribou remains to be seen. Research should focus on the effects of parasites and disease on population parameters such as condition, fecundity, and mortality.

Acknowledgements

I thank the many members of the Fort Smith Hunters and Trappers Association that helped with caribou necropsies. Project funding was by Indian and Northern Affairs Canada and Environment Canada. I thank Harry Armbruster, Margo Pybus, Bill Samuel, Roger Edwards, and Tony Diamond and an anonymous reviewer for improvements to drafts of this paper.

References

Addison, E.M., Hoeve, J., Joachim, D.G. & McLachlin, D.J. 1988. *Fascioloides magna* (Trematoda) and *Taenia hydatigena* (Cestoda) from white-tailed deer. – *Can. J. Zool.* 66: 1359-1364.

Broughton, E. & Choquette, L.P.E. 1969. Additional information and comments on disease conditions and parasites of barren-ground caribou. – *Unpubl. Rep., Can. Wildl. Serv., Ottawa.* 29pp. (Available from the author of this paper).

Holmes, J.C. & Podesta, R. 1968. The helminths of wolves and coyotes from the forested regions of Alberta. – *Can. J. Zool.* 46: 1193-1204.

Huot, J. & Beaulieu, M. 1985. Relationship between parasite infection levels and body fat reserves in George River caribou in spring and fall. – *McGill Subarctic Res. Pap. No.* 40: 317-327.

Lankester, M.W. & Hauta, P.L. 1989. *Parelaphostrongylus andersoni* (Nematoda: Prostrongylidae) in caribou (*Rangifer tarandus*) in northern and central Canada. – *Can. J. Zool.* 67: 1966-1975.

Messier, F., Huot, J., Le Hanaff, D. & Luttich, S. 1988. Demography of the George River caribou herd: evidence of population regulation by forage exploitation and range expansion. – *Arctic* 41: 279-287.

Messier, F., Rau, M.E. & McNeill, M.A. 1989. *Echinococcus granulosis* (Cestoda: Taeniidae) infections and moose-wolf population dynamics in southwestern Quebec. – *Can. J. Zool.* 67: 216-219.

Parker, G.R. 1981. Physical and reproductive characteristics of an expanding woodland caribou population (*Rangifer tarandus caribou*) in northern Canada. – *Can. J. Zool.* 59: 1929-1940.

Pybus, M.J. 1990. Survey of hepatic and pulmonary helminths of wild cervids in Alberta, Canada. – *J. Wildl. Dis.* 26: 453-459.

Samuel, W.M., Ramalingam, S. & Carbyn, L.N. 1978. Helminths in coyotes (*Canis latrans* Say), wolves (*Canis lupus* **L.**), and red foxes (*Vulpes vulpes* L.) of southwestern Manitoba. – *Can. J. Zool.* 56: 2614-2617.

Thomas, D.C. 1982. The relationship between fertility and fat reserves of Peary caribou. – *Can. J. Zool.* 60: 597-602.

Thomas, D.C. & Barry, S.J. 1990. A life table for female barren-ground caribou in north-central Canada. – *Rangifer* Spec. Issue No. 3: 177-184.

Thomas, D.C. & Kiliaan, H.P.L. 1990. Warble infestations in some Canadian caribou and their significance. – *Rangifer* Spec. Issue No. 3: 409-417.

Thomas, D.C. & Kiliaan, H.P.L. 1994. Fire-caribou relationships: (I) Physical characteristics of the Beverly herd, 1980-87. – *Unpubl. Rep., Can. Wildl. Serv. Edmonton, Ab.* 178pp. (Available from the author).