

DISTRIBUTION OF ELAPHOSTRONGYLINE NEMATODES (META-STRONGYLOIDEA: PROTOSTRONGYLIDAE) IN CERVIDAE AND POSSIBLE EFFECTS OF MOVING *RANGIFER* SPP. INTO AND WITHIN NORTH AMERICA

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ABSTRACT: Four species of elaphostrongyline nematodes presently are known from cervids of North America. *Parelaphostrongylus odocoilei* occurs in mule deer, Columbian black-tailed deer, caribou, and mountain goat in western Canada and United States. *Parelaphostrongylus tenuis* occurs in white-tailed deer throughout much of the range of this host in eastern North America. It also occurs in free-ranging wapiti in central Manitoba and is a pathogen of moose where their range overlaps with white-tailed deer in eastern North America. *Parelaphostrongylus andersoni*, first reported in a few disjunct populations of white-tailed deer in the eastern United States and western Canada, also occurs in caribou in northcentral and eastern Canada, including Newfoundland. *Elaphostrongylus cervi* is known in North America only from caribou in central Newfoundland where it probably was introduced with reindeer brought from Norway. Earlier speculation that *E. cervi* also occurs in mainland Canada was based on the presence of dorsal-spined larvae in caribou feces. Specific diagnosis of first-stage larvae is impossible but most of these earlier reports are now thought more likely to have been *P. andersoni* infections. Possible exceptions are reports of unusually long larvae (means >400 μ) from woodland caribou in northeastern Alberta and from the Meally Mountain herd, Labrador. There have been opportunities for *E. cervi* to spread to mainland Canada with introduced reindeer and caribou but there is, as yet, no conclusive evidence that it has become established outside of Newfoundland.

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Elaphostrongyline nematodes (Protostrongylidae: Elaphostrongylinae) are tissue parasites maturing in the central nervous system and/or skeletal musculature of cervids. Four species are presently known to occur in North America. Two of these, *Parelaphostrongylus tenuis* and *Elaphostrongylus cervi* cause neurologic disease. The other two may cause verminous pneumonia and severe myositis. Specific diagnosis is difficult. The four cannot be distinguished on the basis of the dorsal-spined larvae passed in feces of infected animals and recovering the inconspicuous adult worms from tissues requires considerable expertise.

Because of the increased interest in game ranching and ensuing requests to move native cervids and to import exotics, it is useful to review the known host and geographic distribution of these parasites. Historical accounts of moving *Rangifer* spp. into and within

North America are summarized and the possible effect on the distribution of some elaphostrongyline nematodes is discussed.

DISTRIBUTION IN CERVIDS

Parelaphostrongylus odocoilei (Hobmaier and Hobmaier, 1934)

The muscleworm, *P. odocoilei*, was named by Hobmaier and Hobmaier (1934) who recovered specimens from Columbian black-tailed deer (*Odocoileus hemionus columbianus*) in the foothills of the Coastal Ranges, north of San Francisco, California, U.S.A. On the basis of the Hobmaiers' description, the Russian systematists, Boev and Schulz (1950), placed it in its present genus but the absence of subsequent reports of the species later led Boev (1968) to consider it a *species inquirenda*. The following year, however, Brunetti (1969) redescribed the

parasite using new specimens from the type host and locality, as well as from California mule deer (*O. hemionus californicus*), thereby confirming the species' validity.

Almost a decade later, Platt and Samuel (1978) found *P. odocoilei* in mule deer (*O. h. hemionus*) of Jasper National Park, Alberta, Canada. They provided a redescription and designated a new type, because the original had been lost. In 1984, Pybus *et al.* reported *P. odocoilei* in Columbian black-tailed deer on Vancouver Island, in a white-tail/mule deer hybrid in Jasper National Park, and in mountain goat (*Oreamnos americanus*) from near Salem, Washington, U.S.A. and Jasper National Park. More recently, *P. odocoilei* has been found in woodland caribou (*Rangifer tarandus caribou*) of west-central Alberta (Gray and Samuel 1986).

Moose (*Alces alces*), and to a lesser extent white-tailed deer (*O. virginianus*), are suitable hosts for *P. odocoilei* under experimental conditions (Platt and Samuel 1978, Pybus and Samuel 1980, Pybus 1983, Pybus and Samuel 1984), but natural infections have not been reported in these cervids.

Parelaphostrongylus odocoilei appears to be a western species being known from California, Washington, British Columbia, Canada and Alberta. Mule deer and black-tailed deer are probably the most common hosts but more details of the parasite's distribution and its significance in other wild ungulates, particularly mountain goat, are needed (Pybus *et al.* 1984).

Additional reports of unidentified dorsalspined larvae in cervids and bovids within the range of *P. odocoilei* include those by Samuel and Holmes (1974), Pybus *et al.* (1984), and Gray and Samuel (1986).

Parelaphostrongylus tenuis (Dougherty, 1945)

The meningeal worm was first described from white-tailed deer in New York State (Dougherty 1945). Following the discovery by Anderson that *P. tenuis* causes severe neu-

rologic disease in moose (Anderson 1964, 1965), as well as in most other native cervids (Anderson 1970, 1972, Anderson *et al.* 1966), knowledge of its distribution increased (see review in Anderson and Prestwood 1981). It is known only from the eastern half of North America extending in range to the east and north wherever white-tailed deer are found. Details of its westward limits are poorly known. Generally, however, *P. tenuis* occurs in white-tailed deer of Canada as far west as southwestern Manitoba, and, in the United States, east of a line projected south from western Minnesota through the middle of Oklahoma and including the extreme eastern portion of Texas. Meningeal worm is absent in the coastal plain region of the southeastern United States with the exception of an area within the Florida Everglades where white-tails were introduced years ago from Wisconsin (Prestwood and Smith 1969, Prestwood *et al.* 1974).

White-tailed deer is the only normal host of *P. tenuis*. Wapiti (*Cervus canadensis*), although susceptible to neurologic disease, may survive experimental infection and pass larvae (Anderson *et al.* 1966). Naturally infected wapiti also pass larvae (Pybus *et al.* 1989) and their importance in maintaining and spreading the infection is being investigated in Alberta. Some wild moose may also survive infection for underdetermined periods of time (Thomas and Dodds 1988).

Parelaphostrongylus andersoni Prestwood, 1972

Another musclemoorm, *P. andersoni* was first found in white-tailed deer of the southeastern United States (Prestwood 1972). It appeared to be limited in its distribution to the southern mixed, and oak-hickory-pine vegetation types of the coastal floodplain (Prestwood *et al.* 1974). Single or concomitant infections with *P. tenuis* were rare in these areas. A report of *P. andersoni* in a white-tailed deer in New Jersey (Pursglove 1977) was followed by another by Pybus and

Samuel (1981) who found 75% of white-tails in southeastern British Columbia to be infected. The latter authors suspected that this species is much more widely spread in white-tailed deer than indicated by the literature.

In 1989, *P. andersoni* was reported in woodland caribou of northwestern Ontario and of northern Quebec and Labrador (George River herd) and in barren-ground caribou of central Northwest Territories (Beverly herd) (Lankester and Hauta 1989). Recently we also found *P. andersoni* in caribou on the island of Newfoundland (unpubl. data). This wide distribution suggests it may be an ancient parasite of *Rangifer* spp. If so, *P. andersoni* would also be expected to occur in *Rangifer tarandus* of Asia but no such report exists. Alternatively, it may have a North American origin, possibly in white-tailed deer.

In more recent times, *P. andersoni* could have spread between caribou and white-tailed deer in areas where the ranges of the two have infringed on each other. If originally a parasite of *Rangifer* spp., it could also have been transferred as a result of the numerous caribou relocations documented herein and by Bergerud and Mercer (1989). More southerly records of *P. andersoni* in the southeastern States could have resulted from introducing deer from northern locations.

Parelaphostrongylus andersoni may be spread generally or sporadically across the range of white-tails, even in eastern North America where they also have *P. tenuis*. Lankester and Hauta (1989), noting the rarity of concurrent infections of *P. andersoni* and *P. tenuis* found by Prestwood *et al.* (1974), suggested that cross-immunity or some other form of interaction may exist between the two nematode species and affect their distribution in white-tailed deer. On the other hand, when easier methods are available to detect *P. andersoni*, concurrent infections with *P. tenuis* may prove to be common.

Dorsal-spined larvae reported in feces of woodland caribou in isolated herds in north-

western Ontario and east-central Manitoba (Lankester *et al.* 1976, Lankester 1976) are now thought to have been those of *P. andersoni* rather than *E. cervi*, as was suggested at that time (Lankester and Hauta 1989).

Elaphostrongylus cervi Cameron, 1931

An elaphostrongyline nematode occurs in the central nervous system and in skeletal muscle of caribou in central Newfoundland. It was reported as *Elaphostrongylus cervi* by Lankester (1976) and Lankester and Northcott (1979). Worms mentioned earlier by Peters and King (uncirculated report to the Government of Newfoundland and Labrador, 1959) as *Elaphostrongylus* sp., and by Bergerud (1971) as *Elaphostrongylus* sp. and *Pneumostrongylus* sp., were undoubtedly the same parasite. This worm has not been found anywhere in mainland Canada. Earlier speculation that *E. cervi* may exist in caribou of northwestern Ontario, central and northwestern Manitoba, and Labrador (Lankester 1976, Lankester *et al.* 1976, Lankester and Northcott 1979) was based on larval morphology only and probably is incorrect. More recent work (Lankester and Hauta 1989) reveals that *P. andersoni* is widespread in caribou of these regions.

Elaphostrongylus cervi from Newfoundland is not specific to caribou. Larvae originating from caribou in central Newfoundland were allowed to develop in snails and were given to a moose calf (Lankester 1977). The calf developed severe neurologic signs and adult worms identified as *E. cervi* were recovered from the central nervous system and among muscles of the shoulders. The calf also passed dorsal-spined larvae that were $370 \pm 17 \mu$ long, beginning 64 days after infection. However, we now know that *P. andersoni* exists along with *E. cervi* in caribou of central Newfoundland (unpubl. data). Because earlier experiments (Lankester 1977) using infective larvae from caribou of this area could have included both species, it cannot be determined whether one or both

became patent in the moose calf. Neurologic disease has not been seen in wild moose in Newfoundland but dorsal-spined larvae ($340 \pm 420 \mu$ long, $\bar{X} = 388 \mu$) have been found in 1 of 63 moose fecal samples examined from the Topsails and Middle Ridge areas (unpubl. data).

Dorsal-spined larvae found in feces of woodland caribou of northeastern Alberta in the vicinity of Ft. McMurray by Gray and Samuel (1986) deserve special comment. Their greater length ($451 \pm 17 \mu$) lead the authors to suggest that they may be *E. cervi*. Information presented later in the present paper documents that reindeer, originally from Norway, were shipped from Newfoundland destined for the Great Slave Lake area. Some escaped along the way in northeastern Alberta and may have given rise to a focus of infection. Similarly, long, first-stage, dorsal-spined larvae ($405 \pm 16 \mu$ long) were collected off range of the Mealy Mountain caribou herd, east of Goose Bay, Labrador (Lankester and Hauta 1989). Reindeer from Newfoundland also were relocated to Lobster Bay, near St. Augustine, Quebec, approximately 300 km southeast of the present range of the Mealy Mountain caribou herd. The possibility that *E. cervi* became established at these locations needs to be investigated.

Notwithstanding, *E. cervi* is so far confirmed only from Newfoundland and was probably introduced there. However, before considering the evidence for this suggestion, it is necessary to briefly mention the differing views regarding the proper scientific name of the elaphostrongyline nematode in *Rangifer* spp. Material from caribou of Newfoundland is morphologically similar to *E. rangiferi* described by Mitskevich (1958, 1960) from reindeer (*Rangifer tarandus tarandus*) in the USSR (Lankester and Northcott 1979). The worm in reindeer of northern Scandinavia is thought to be the same species (Halvorsen *et al.* 1989, Steen *et al.* 1989). However, *E. rangiferi*, as well as *E. panticola* described from red deer (*Cervus elaphus si-*

biricus) in Asia (Lyubimov 1945), has been considered a synonym of *E. cervi* (see Kutzer and Prosl 1975, Lankester and Northcott 1979). Other workers have, instead, considered the two species, *panticola* and *rangiferi*, to represent subspecies of *E. cervi cervi* (Pryadko and Boev 1971). *Elaphostrongylus cervi* was described originally by Cameron (1931) from red deer (*Cervus elaphus*) in Scotland.

More recently, additional information has been published that supports splitting rather than lumping the species of *Elaphostrongylus*. Halvorsen *et al.* (1989) exposed reindeer calves to *Elaphostrongylus* originating from reindeer, red deer, and moose in Norway. Only the worms from reindeer produced patent infections; no larvae were detected in feces of reindeer given material from moose or red deer. As a result Halvorsen *et al.* (1989) believe that the name *E. rangiferi* should be reserved for worms from reindeer and *E. cervi* should be reserved for worms from red deer. They also suggest that worms from moose may represent an undescribed species. Steen *et al.* (1989) have recently given the new name, *E. alces*, to specimens from moose in Sweden.

It is not the purpose of this paper to resolve the correct scientific name of the elaphostrongyline worm in caribou of Newfoundland. That will require more detailed morphological, biological, biochemical, and possibly, genetic study of material from the range of hosts and geographic areas where *Elaphostrongylus* occurs. For the purpose of this paper, we opt to continue to use the name *E. cervi* for material in caribou of Newfoundland, in keeping with the first reports of its occurrence in Canada and to prevent confusing the issue further until definitive answers regarding its correct name are available.

THE IMPORTATION AND RELOCATION OF RANGIFER

With *E. cervi* (or *E. rangiferi* as it is known to some) in reindeer of Norway and *P.*

andersoni in caribou over much of their range in Canada, the following accounts of the importation and relocation of *Rangifer* may help to explain the known and potential distribution of these elaphostrongyline nematodes in cervids of North America.

Although probably only a partial history, this record of animal movements does identify certain localities where closer examination of caribou would be fruitful in arriving at a more complete understanding of the distribution of this group of parasites.

Reindeer from Norway to Newfoundland, 1908

As related in a detailed and interesting account by Arthur Johnson (1962, 1967), Sir Wilfred Grenfell arranged the purchase and shipment of 300 reindeer from Altenfjord in the Lapland region of Norway. They were landed about 13 km south of St. Anthony, Newfoundland at Crémaillère Bay on January 20, 1908. Fifty of these animals were to have been dropped off at Lewisporte for the Anglo-Newfoundland Development Co. at Grand Falls but ice in Notre Dame Bay prevented landing. Instead, a young Newfoundlander, Mr. Hugh Cole, was charged with herding the animals overland for a distance of about 640 km to a final destination at the Company's base at Millertown in central Newfoundland. The 58-day trek during unusually severe weather of March and April took them eastward from St. Anthony, southward down the "roof" of the Northern Peninsula, eastward to Sop's Arm, westward across to Parson's Pond, then southward, with the animals swimming across St. Paul's Inlet and continuing via Bonne Bay and Deer Lake to a corral prepared at Millertown at a site called "Lapland" near the Mary March River. Remains of the old corral can still be seen on a grass-sedge plateau above Red Indian Lake and east of Buchans Junction (authors).

On the way south, the reindeer mingled at night and during snowstorms with the Northern Peninsula caribou and at least one cow

permanently joined them. Later, at Mary March River, the corral was often left open and the reindeer and caribou, of what is now known as the Topsails herd, apparently ranged together back and forth during the rut. Of the 50 animals starting out, 38 were cows. Twenty-five calves were reared in May.

The lack of natural food at the holding site and the Company's loss of interest in the herd led to their being offered back to Grenfell. Following the breeding season that same year, they were lead northward to South Brook on Halls Bay and loaded onto a schooner. They reached St. Anthony to join the original herd in late November. The herd at St. Anthony flourished. While providing meat for the hospital and being the source of stock for a few relocations, it grew to between 1200 and 1500 animals by 1913. However, on Grenfell's return to Newfoundland after the First World War, the herd had declined to 230 reindeer due to "bronchial disease", poaching, and large groups having escaped to the south (Rutherford *et al.* 1922, Johnson 1962, Scotter 1972).

From this historical account of the rise and fall of reindeer on the island of Newfoundland, it is quite possible that the founding animals from Norway, if infected with *E. cervi*, could have been responsible for transmitting it to native caribou where it is now well established in the central herds (Lankester and Northcott 1979, unpubl. data). A further test of this hypothesis would be the absence of *E. cervi* in caribou of the isolated Avalon Peninsula of southeastern Newfoundland. The Peninsula is separated from the main part of the island by a narrow neck of land and the central herds to the northwest as well as the herd on the Avalon have been greatly reduced in numbers until recent times (Bergerud 1971, Bergerud *et al.* 1983). Therefore, there has been little opportunity for caribou to cross onto the Avalon since the reindeer introduction. It also should be noted that the caribou relocations on the Avalon Peninsula recorded by Bergerud and Mercer

(1989) involved stock from the native Avalon herd rather than from the central herds (Mercer, pers. comm.). So far we have examined 10 caribou from the Avalon herd near Peter's River Rd. and none was infected with *E. cervi* (although *P. andersoni* did occur (unpubl. data)).

It is not clear whether reindeer were ever transported into Labrador and given the opportunity to mix with the herds there. Johnson (1962) cites mention in Grenfell's letters of two lots of 25 reindeer having been sent to the "clubs" which he presumed were the Labrador Missions. No further details were available to us on what the precise locations might have been. Many years later, a large introduction of reindeer, likely from Scandinavia, was planned for the Lake Melville area near Goose Bay, Labrador, but it was abandoned with the outbreak of the Second World War (Johnson 1962). Presently, the Red Wine Mountain caribou herd is found northwest of Lake Melville and the Mealy Mountain herd is to the southeast (Jackson 1986). The Mealy Mountain herd is where Lankester and Hauta (1989) found dorsal-spined larvae with a mean length greater than 400 μ that might indicate *E. cervi* is present. The only reindeer introduction known for certain to have occurred in the Labrador region is that at Lobster Bay about 300 km to the south and just within the present-day boundary of Quebec near St. Augustine.

Reindeer from Newfoundland to Fort Smith, N.W.T., 1911

The relocation of 50 reindeer from St. Anthony to Fort Smith is well documented in government reports (Campbell 1915, 1916), in other accounts written shortly after the event (Jones 1913, Rutherford *et al.* 1922), and in personal interviews conducted many years later with Mr. Billy McNeill (Hedlin 1961, Inglis 1969). McNeill, a native Newfoundlander, was one of three men employed by the Canadian Department of the Interior to

deliver the animals to Hardisty Island in Great Slave Lake where suitable range had been selected. These historical articles present an exciting story, most of which must be omitted here, with the exception of details that help to evaluate the likelihood of *E. cervi* having been passed from the reindeer to native caribou of northeastern Alberta.

The animals were transported in the fall of 1911 by steamer from St. Anthony, by rail from Quebec, by wagons along the Athabasca Trail from Stoney Creek, east of Fort Edmonton (Edmonton), and onto scows at Athabasca Landing for the 800 km trip down the Athabasca River to Lake Athabasca and down the Slave River to Fort Smith. By late October they had reached a point along the Slave River, 19 km north of Chipewyan on Lake Athabasca, and could go no further because of ice. There was an abundance of lichen in the area and it was decided to unload the remaining 33 reindeer and spend the winter. The animals never strayed from camp "more than a mile or two". Over winter a bull went through the ice and a cow wandered away. In early May of 1912, they resumed their trip down the Slave to Fort Fitzgerald and then another 48 km east by land to Big Whitefish Lake where a fence was constructed across a peninsula. It was thought that the animals would not leave by swimming. The next morning all were gone. After travelling 160 km to the south on foot, the herders caught up with the animals at the broad mouth of the Peace River. Only 12 were found. They were corralled close to Fort Smith over the next two years during which time one disappeared and 8 more escaped. It took 3 months to round them up. More died in captivity. In the summer of 1914, the remaining 2 reindeer (one account says 4) were taken by scow down the Slave River and up to Waite Island (or Moose Deer Island) in the north arm of Great Slave Lake just off from Fort Resolution. One died over winter. When orders were received to terminate the project, the last surviving reindeer was taken

to Fort Resolution on Dominion Day, 1916, and eaten.

If any of the reindeer taken into northern Alberta were infected with *E. cervi*, events described in these historical accounts could conceivably have led to establishing the parasite in native caribou. Further efforts should be made to identify the nematode in woodland caribou in the vicinity of Fort McMurray where Gray and Samuel (1986) found unusually long, dorsal-spined larvae.

Reindeer from Newfoundland to Lobster Bay, Que., 1918

In 1918, the last of Grenfell's reindeer herd (125 animals) was taken over by the Canadian Government and shipped to the north shore of the Gulf of St. Lawrence, near St. Augustine (Rutherford *et al.* 1922). The animals wintered on range near Lobster Bay. During summer they were confined by fencing to a peninsula between Lobster and Rocky Bays. During the first winter, several reindeer escaped and at least 6, and possibly as many as 17, were never found. The herd was maintained at Lobster Bay until 1923.

Reindeer from Lobster Bay to Anticosti Island, 1923

In August, 1923 (Anon 1925), or 1924 (Wright cited in Bergerud and Mercer 1989) about 145 reindeer remaining in the Lobster Bay herd were moved to Anticosti Island in the mouth of the St. Lawrence River. Prior to being shipped, they had been moved temporarily to the Dog Islands for protection from wolves (Anon 1924). White-tailed deer were already present on Anticosti Island when reindeer arrived and Bergerud and Mercer (1989) conclude that *P. tenuis* probably contributed to their decline. The last reindeer was seen on the island in 1949 (Cameron 1958).

Reindeer from Siberia to Alaska, 1891-1902

The well known introduction of reindeer to Alaska began with 1,280 animals brought from Siberia over a three year period (Brady

1968, Scotter 1972). The herds exceeded one-half million animals by 1930 but were reduced to about 25,000 by the mid-1950's. Most were herded along the western coast of Alaska while others were established on off-shore islands (Hanson 1952, Scheffer 1951). Hadwen and Palmer (1922) described the important parasites of Alaskan reindeer at that time. To this day, an elaphostrongyline nematode has not been reported from reindeer in Alaska (Dau 1981) but it is not known whether anyone has looked thoroughly enough.

Reindeer from Norway to Alaska, 1898

There is at least one record of reindeer from Norway being landed in southeastern Alaska to be used as draught animals to haul badly needed supplies to mining camps along the upper Yukon River (Jackson 1897, Ray and Richardson 1898). In February 1898, Dr. Sheldon Jackson landed in New York with 538 reindeer from Lapland. They were taken by rail to Seattle and arrived by steamer in Haines Mission, Alaska, in late March. Only 12 animals died en route. Apparently, because the emergency along the Yukon had passed, the accompanying Lapp drivers and their families, as well as 326 reindeer, were immediately turned over to the Department of the Interior. The fate of these animals, that could have carried *E. cervi*, is not known to us.

Caribou from Newfoundland to Caribou Island, Ontario

In about 1904 or 1905, Mr. C.S. Osborn who later became Governor of Michigan, arranged the shipment of 6 caribou from Newfoundland to be stocked on a small privately owned island (608 hectares) in the eastern end of Lake Superior (Carter 1979). They travelled by train to Sault Ste. Marie, Michigan, by steamer to Michipicoten Island and the rest of the way to Caribou Island by tug. By 1912 there were about 50 animals on the island. One shot a few years later weighed

over 700 pounds leaving no doubt that it was a caribou and not a reindeer. One winter (no date mentioned), Lake Superior froze completely to the mainland and the population, estimated to be "several hundred animals", left the island. After several years, a few animals believed to have been born on the island, returned. By 1934 the island was judged to be over-populated and part of the herd was removed by the Ontario Ministry of Game and Fisheries to the north shore of Lake Superior. The last caribou on the island was believed to have been killed in 1950.

These animals were transported off Newfoundland before reindeer arrived in 1908 and would not have been infected with *E. cervi*.

Reindeer from Norway to Baffin Island, 1921

A subsidiary of the Hudson's Bay Company purchased reindeer in Norway and landed about 550 in Amadjuak Bay on Baffin Island November 1, 1921 (Stefansson 1964, Scotter 1972). The animals scattered on arrival. The herders were later able to round up only 260. By the summer of 1923, only 181 remained in the herd and all of these disappeared during the winter of 1924-25.

Reindeer from Norway to Michigan, 1922

The State of Michigan obtained 60 reindeer from Norway and released them in denuded timberlands (Johnson 1962). The introduction failed, possibly because of *P. tenuis* (our speculation). These were likely the same animals that Hadwen mentions inspecting (Hadwen and Palmer 1922).

Reindeer from Alaska to Mackenzie Delta, N.W.T., 1935

The trek with 3,400 reindeer started from the Kotzebue region of Alaska in 1929 and did not reach the Mackenzie River until 5 years later (Hanson 1952, Johnson 1962). In March, 1935, delivery was made of 2,370 head near Kittigazuit (Porsild 1954). Most of these animals had been born along the way. It

was thought that no more than 10 percent were animals that had left Alaska (Scotter 1972). The Mackenzie Delta Reindeer Grazing Reserve was established on the upland tundra above Reindeer Station on the eastern channel of the Mackenzie River. Here the herd fluctuated between about 5,000 and 9,000 animals (Krebs 1961) with lower numbers recorded in the late '60's (Scotter 1972). Up to 1969, natural losses and strays accounted for about 30,000 reindeer. Throughout these years, native caribou infringed on the Reserve (Kelsall 1968). Elaphostrongyline nematodes were not among the parasites reported from the reindeer by Choquette *et al.* (1957).

Animals from this herd were shipped to a private game farm in Southern Alberta in the mid-1980's and about 250 are to be relocated to game farms in the area of Dawson Creek, British Columbia, in February, 1990.

Caribou from Saskatchewan to Minnesota, 1938

Ten caribou captured in northern Saskatchewan were moved in June 1938 to a bog north of Red Lake, Minnesota. None could be found by 1946 and they probably succumbed to predators and *P. tenuis* (Bergerud and Mercer 1989).

Caribou from Newfoundland to Nova Scotia, 1939

Twelve caribou from Newfoundland were released in the Liscombe Game Sanctuary of Nova Scotia (Tufts 1939). Their exact origin is not recorded but in all likelihood they came from one of the central herds rather than that on the Avalon Peninsula (Mercer, pers. comm.). The introduction failed, probably because of *P. tenuis* (Benson and Dodds 1977).

Caribou from Northeastern Quebec to Cape Breton and Laurentide Pk., 1968-72

Fifty-one caribou from northeastern Quebec (51° 30'N, 65° 10'W and 53° 00'N,

68°00'W) were released in Cape Breton Highlands National Park, Nova Scotia in 1968 and 1969. By 1973, none could be found. *Parelaphostrongylus tenuis* from white-tailed deer is thought to have been responsible (Dauphine 1975). Eighty-two caribou from northeastern Quebec were released into Laurentide Park, Quebec, between 1966 and 1972. White-tailed deer do not occur in the park and the caribou continue to prosper (Bergerud and Mercer 1989).

Reindeer from Norway to Great Cloche Island, Ontario, 1970

Twelve reindeer from Norway were released into an enclosure on a private island in the North Channel of Lake Huron. White-tailed deer had occupied the area before the enclosure was erected. Ten months after their introduction in May, all were infected with *P. tenuis* and 7 had died (Anderson 1971, 1972). Eventually all succumbed to neurologic disease.

Caribou from Newfoundland into Maine 1963 and 1986

In December 1963, 29 caribou were taken from the Buchans Plateau area of central Newfoundland (Mercer, pers. comm.) and released in Maine in the vicinity of Mt. Katahdin (Dunn 1965). The animals were taken from an area where caribou are infected with *E. cervi*. They dispersed from the release site the following spring into areas with white-tailed deer and none was seen after 1966 (Bergerud and Mercer 1989).

More recently in October, 1986, 23 caribou were taken from the Peter's River Rd. area of the Avalon Peninsula of Newfoundland and released into an enclosure at the University of Maine, Orono (McCullough 1988). A few of these animals were passing dorsal-spined larvae in their feces on arrival but after repeated treatment with ivermectin, larvae were no longer detectable in feces (McCullough, pers. comm.). As explained earlier, caribou on the Avalon where the 1986

animals originated, appear to be infected only with *P. andersoni* and not *E. cervi*.

Caribou from Newfoundland into Wisconsin, 1972.

Caribou referred to as *R. t. terraenovae* and presumably from Newfoundland originally, were reared over a five-year period isolated from other cervids in a commercial game preserve in Wisconsin. Fourteen eventually were released into a 2640 hectare enclosure containing about 600 white-tailed deer. All caribou were dead within 6 or 7 months due to *P. tenuis* infection (Trainer 1973).

Local relocation of Caribou.

Nearly 400 caribou were released at 22 sites around the coast of Newfoundland and on off-shore islands from 1961-82 (Bergerud and Mercer 1989). Stock for 20 of these relocations came from the native herds on the Northern Peninsula or of central Newfoundland. Two relocations on the Avalon Peninsula used stock from the native herd on the Avalon (Mercer, pers. comm.).

From 1982-86, The Ontario Ministry of Natural Resources relocated caribou from the Slate Islands, Lake Superior, to Michipicoten Island, Montreal Island, and Bowman and St. Ignace Islands, all in Lake Superior (Bergerud and Mercer 1989). The islands were free of white-tailed deer and most of the introductions have persisted.

These efforts to rehabilitate populations within their original ranges have not likely altered the distribution of cervid parasites but the events are mentioned here for sake of completeness.

CONCLUSIONS

Reindeer brought to North America from Norway probably were infected with *E. cervi* and transmitted it to caribou in Newfoundland. The possibility that *E. cervi* was later introduced to caribou in at least two other locations in mainland Canada needs to be

investigated. It is not known if reindeer from Siberia are infected with an elaphostrongyline nematode that might have been brought to Alaska and the western Canadian Arctic.

Elaphostrongylus cervi in Newfoundland can produce neurologic disease in moose but it is not known if patent infection results. White-tailed deer could have been exposed to *E. cervi* in reindeer brought to mainland Canada, however, it is not known if the parasite matures in this host.

Parelaphostrongylus andersoni is widely distributed in native caribou and it may have been carried with them to several relocation sites in Canada and in the United States. White-tailed deer also are known hosts of *P. andersoni*.

Caribou and reindeer, relocated to many areas in eastern North America where white-tailed deer occur, have not survived, probably because of *P. tenuis*.

Parelaphostrongylus odocoilei, which is common in west coast deer, is found in caribou of northeastern Alberta as well as in mountain goats.

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